POWER PLANT ENGINEERING

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Cincinnati Plant of National Lead Co.

MODERN EQUIPMENT INTRODUCED TO SECURE THRIFTY OPERATION. STEAM UTILIZED FOR LEAD DRYING AND LAUNDRY

AMONG the new plants notable for economy of power production, is the Cincinnati plant of the National Lead Co. which annually reduces 9000 tons of white lead, in addition to tons of babbit metal, bar solder, lead pipe and other lead products.

In 1917, the company decided to make many changes in their plant, replacing antiquated buildings and equipment with modern reinforced concrete structures and the latest types of apparatus and machinery; today their entire plant consists of modern concrete structures with large window areas for light and ventilation. One of the new structures, four stories in height, was especially designed to accommodate the power plant and the lead crushing and screening apparatus, with ample room for a very complete machine shop and steam laundry on a portion of the second floor.

In the new plant ample steam is generated by a battery of two 250-hp. water-tube boilers, space in boiler room being provided for the future addition of another battery. These boilers operate at 125 lb. pressure and are equipped with soot blowers and the modern apparatus essential to close regulation and right operation. Automatic stokers, of the dutch oven type furnaces, are provided.

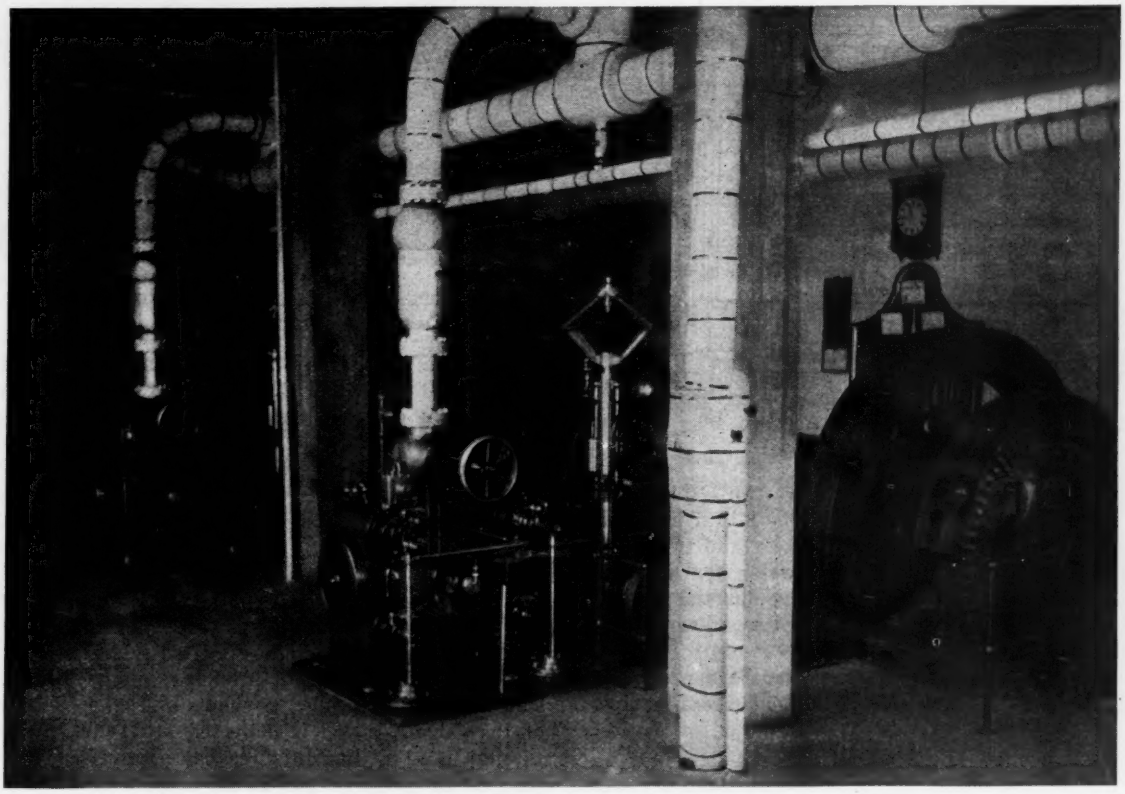


FIG. 1. VIEW OF ENGINE ROOM SHOWING POSITIVE DRIVE CORLISS TYPE UNITS

Coal arriving at the plant on the railway siding is discharged into a receiving hopper and after passing

through a single-roll crusher is elevated by a bucket conveyor and tripped into either of the three 100-ton concrete bunkers, located over the boiler room, and which are equipped with 12 by 12-in. clam shell discharge valves. All coal is weighted in a traveling weight hopper before delivery to the furnace hoppers. Ashes are discharged into the bucket conveyor, passing under the furnaces, elevated and tripped into a 40-ton concrete ash bin over the railway siding. The ashes are discharged through an 18 by 18-in. clam shell valve and a hinged chute into gondola cars. Figure 2 shows in diagram, the arrangement of the coal and ash handling system.

Feed Water and Pumps

A large percentage of feed water is condensate pumped to a gravity storage tank on the third floor of the plant, which discharges directly to an open feed water heater having large storage capacity, located on the engine room floor and connected as shown in Figs. 3 and 4. Automatic regulation is provided to control the proper flow to the heater. Makeup and service water is drawn from a 25,000-gal. cistern receiving city water slightly warmed after its use in one of the metal cooling processes.

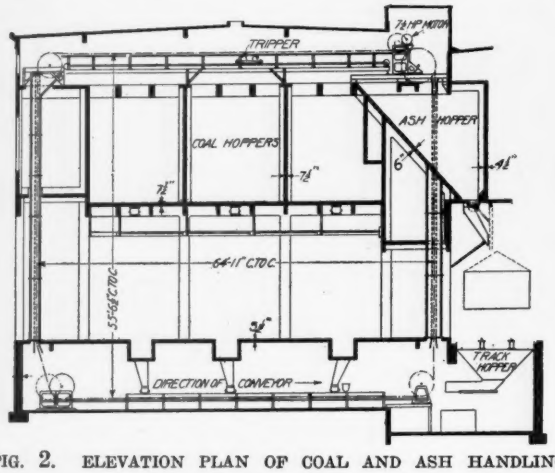


FIG. 2. ELEVATION PLAN OF COAL AND ASH HANDLING CONVEYOR SYSTEM

Arranged as shown in Fig. 4 are two 7½ by 4½ by 10-in. duplex feed pumps, two 5½ by 8 by 7-in. simplex vacuum pumps for the heating system, and two vertical deep well pumps which supply water for a treating process. One feed pump discharge line is a turbine (H) type water meter, to record water delivered to the boilers.

Emergency city water connections are provided at the feed water heater and at the boiler feed pumps.

Steam Piping

Extending across the boilers is an auxiliary steam line, supplied by 2-in. branch connections, close to the boiler, for supplying steam to the various pumps, independent of the steam main. This auxiliary line also supplies steam through a 1½-in. pressure reducing valve for use in the washer, dryer and ironer of a laundry located on the floor above.

All steam piping is valved to permit various steam flow paths and with several branch tees closed by blank flanges for future needs.

Steam from each boiler passes through an automatic non-return boiler stop valve and connected through five bends to the 8-in. header loops in the boiler and engine rooms, arranged as shown in Fig. 4. These mains are covered with 85 per cent magnesia, varying in thickness from 1 to 2 in., according to size of pipe. The steam mains, separators over each engine, and the various bleeders are connected through steam traps arranged to discharge into the feed water heater.

Engine and Generators

Direct-connected to two 225-kv.-a. generators are two 16 by 30-in., 250-hp. engines, as shown in Fig. 1. These are of the positive drive Corliss type and operate

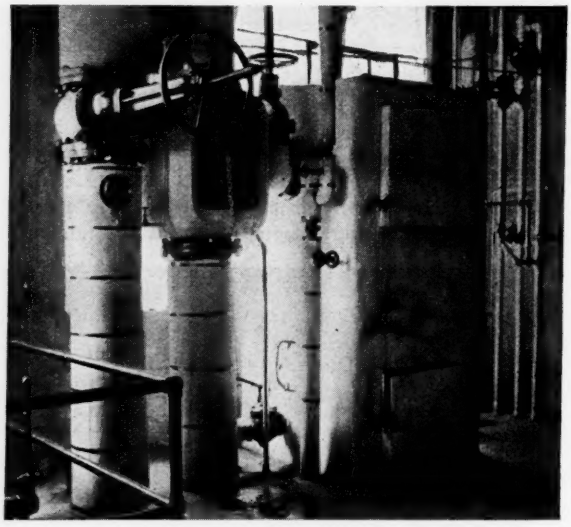


FIG. 3. OPEN FEED WATER HEATER WITH AUTOMATIC REGULATING VALVES

at 164 r.p.m. With these units, current is generated at 225 volts, 3-phase and 60 cycle. Exciting current is furnished by direct-connected 12-kw. machines.

Direct current for a crane motor, elevators and a certain number of motors in the plant is furnished by a 50-kw. generator, belt driven by a 75-hp. alternating current motor.

Exhaust Steam Serves a Double Purpose

Exhausting from the engines, the steam enters a 12-in. main, from which part is drawn through the oil separator into the vacuum feed water heater, or bypassed to the atmosphere through a similar 12-in. line and back pressure valve, as shown in Fig. 4. The bulk of the exhaust steam is delivered at 1½ lb. pressure, through a 12-in. line to three batteries of lead drying pans 86 ft. by 10 ft. and 16 in. deep, with steam jacketed copper bottoms. Three of these pans, one above the other, constitute a battery. Care is taken not to permit the exhaust pressure to exceed 1½ lb., which would cause buckling of the pans. Steam from these pans is then used in a vacuum return heating system serving eight buildings with approximately 75,000 sq. ft. of floor space.

When the engines are not operating, or when necessary during very cold weather, a certain amount of live steam is supplied to the heating system through a 6-in. line by means of a pressure reducing valve, as shown in Fig. 4.

Laundry and Washrooms

As previously mentioned, a portion of live steam is supplied to a complete laundry on the second floor of the power building. Here workers' towels and overalls are laundered free and extreme measures taken to safeguard their health. Two baths a week on the company's time are imperative, and modern shower bath rooms, clean clothes and other facilities are provided to make cleanliness a pleasant duty. This company was the sponsor for a bill enforcing cleanliness among lead plant workers. On the second floor of one building is located the "Welfare Department," where the wash and locker rooms are located. At quitting time, the men leave their overalls in the lockers of one room, pass into the wash room, equipped with wash bowls and shower baths, and from there into a second locker room containing their street apparel.

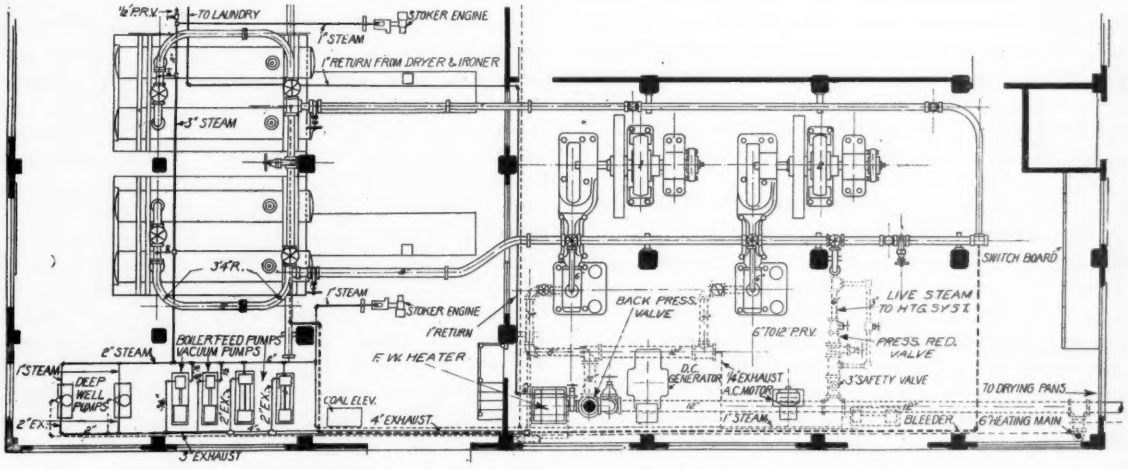


FIG. 4. DETAILED OUTLINE OF BOILER AND ENGINE ROOM SHOWING CONNECTIONS

Each Department Charged for Current Used

From a 6-panel switchboard, current is distributed to the various buildings, and each of the eight departments is supplied with current through meters and is charged for the current it uses.

Approximately 50 motors, varying from 5 to 75 hp., comprise the bulk of the electrical load. These operate crushers, screens, water mills, chasers, oil mills, elevators, conveyors, hydraulic lead presses, etc., as well as the system of exhaust fans for collecting lead dust in various departments.

She was the new stenographer. Coming hurriedly into the General Manager's office, she blurted out: "Why, that man in charge of the factory is a horrid thing."

"What has he done?"

"Well, one of the men told him that he could not keep an old girl in step and he told him to 'throw her out.'"

Hydraulic Power in Construction

Crippled transportation facilities and the shortage of coal in France has compelled many factories to move nearer the source of their raw materials, and particularly nearer to natural water supplies, for power purposes.

Already many textile factories have been transferred from the long-established textile centers of Roubaix and Turcoing to the environs of Grenoble in the Alpine district. Flourishing iron industries also have changed their locations.

Before the war, a project had been formed for the exploitation of the water power of Savoy Dauphine district. Its success at present seems assured. Factories employing 570,000 hp. are now operating in the district and others are under consideration which will require 250,000 hp.

Furthermore, a committee has been appointed to organize and exploit hydraulic power and to encourage improvements and output of hydraulic machines.

Congestion of the Parisian industrial centers is another problem that the manufacturers are facing in re-establishing their industries on a peacetime basis. The industrial population at Lyons tripled in a little more than two years. The American Red Cross, by welfare work among women and children, has done much to relieve the hardships bound to result from such an unprecedented influx.

Wall Street Journal states that, according to a prominent oil man, growing scarcity of high-grade oil in the United States has been one of the factors speeding development of oil resources of South America. He adds that Colombia and Venezuela promise to be the two leading oil-producing countries of the future.

"The whole problem of Americanization would be met in 20 yr. if the nation could systematically grapple with the child problem and insure proper conditions of birth, education and nutrition. In order to accomplish this, the conscience of every separate community must be developed."—Herbert Hoover.

Progress of Power Engineering---I

Analysis of the Recent Developements in Europe Based on the U. S. Consular and Commercial Reports. The Future Offers Great Opportunities for American Trade. By L. W. Alwyn-Schmidt

THE RETURN of peace has brought a set of power engineering problems quite by themselves. They range from the improvement of firing devices in the boiler houses to the erection of vast power houses destined to supply thousands of factories with energy. More power will be required in future than in the past because it will become necessary to supplement human energy by machine power if we shall ever return again to normal production and normal prices. Consequently power engineering finds much attention all over the world. Interest of course centers in the power problems of the European territories destroyed by the war. Here all the primary power equipment was practically wiped out. Power engineers had their first opportunity since the introduction of modern power engineering to reconstruct a power distribution system from the ground. How France, therefore, will solve its power problems of today, how power distribution will be handled in the devastated territories of Belgium and Eastern Europe is a matter of considerable interest. What is learned there will find application in many other countries where virgin conditions are still in existence as in South America, in Africa and Asia.

The French and Belgian Power Field

No definite step has yet been taken for the proper organization of power distribution in Northwestern France. The structures that have been erected to take care of the immediate needs of the neighborhood are of a temporary character only and will be replaced as soon as engineers and consumers have found the best solution for the peculiar demands of industrial France. In the meantime, great progress is made with developing the water power resources of Southern France. The canalization of the Rhone, for instance, offers exceptional opportunities to bring power to many cities along its course and great hope is set on the energy of this river for the development of a machine-operated farming life in Southeastern France. The Rhone has a considerable drop along its lower reaches which have a length of 176 mi. Along this distance a number of dams are under construction that can be used effectively for power production and the present estimate of hydraulic power shows a minimum of 427,000 hp. and an average development of nearly 800,000 hp. that will be available for at least six months every year. Sufficient capital for this scheme is said to have been found in France, but it is doubtful whether the financial resources of that country will be sufficient to take care of the total expenditure to be incurred in the erection of the generating stations, the distributing lines, etc. American enterprise has, therefore, been invited to take part in the development, and it is not unlikely that American contracting firms will enter the French field not only on the Rhone but also for the construction of power houses in the northern districts and in the Pyrenees.

In Belgium temporary structures have been used in most instances to give early relief to the industries. An enormous quantity of electrical and steam power equipment has already gone into Belgium, coming partly from Germany in replacement of that taken from that country during the earlier parts of the war. Belgium, therefore, does not seem to have at the present moment any lack of power equipment. But the country has learned much during the war of general industrial organization and it is expected that more power will be required in the future than in the past. Among the new projects entailing the use of electrical power must be mentioned the intended electrification of most of the Belgian railroads of which a part has already been taken in hand.

The Eastern European Power Field

Conditions in Poland and Bohemia are still somewhat chaotic. The Bohemian industry is well supplied with power, but Poland has suffered much during the war and will require considerable quantities of steam power equipment to be used in connection with its large coal supplies, before it can resume industrial activity on a pre-war scale. Much depends in all these countries on the attitude taken by Germany. The German nation, beaten during the war, still holds enormous economic forces which will exert themselves to good or evil as the case will be in Europe. Modern Germany comes to its reconstruction problems with a set of entirely new political ideals and we must see first how it proposes to employ these in the rebuilding of its industrial life. Having lost much of its coal by the cession of large territories in the East and West, it will have to make up the loss by new sources of power which it proposes to utilize by the erection of large power houses on the Rhine and other German rivers. Large power plants will also be established in the coal regions left to Germany and the newly won power will be transferred by the use of transmission lines all over Germany. With the aid of these power stations it is hoped not only to operate many of the German industries by electrical power, but also to carry out if possible a complete electrification of all German railroads.

To make possible such an enormous scheme of centralization of electrical generation, it has been proposed to nationalize all electrical power supply. The law promulgated for this purpose empowers the government to take over all transmission equipment carrying more than 50,000 v., all property in establishments that produce more than 5000 kw., and all rights of development of electrical power from hydraulic scources of a likely capacity of more than 5000 kw. A credit of 1,000,000,000 marks is asked to enable the Secretary of Finance to carry out the law. Naturally this proposition has received much criticism from various sources, engineering and private, and changes may be made in the law before it is passed by the Reichstag. It is said that only 200 of the 4000 electrical generating stations will be taken over by the government under the law but that these represent approximately three-quarters of all the electrical power supply of Germany. When,

and if, the law has become effective the country will be divided into a number of distributing districts which will each be supplied by a number of power stations particularly suitable for the demands of the district. If the German scheme should work out well it will, no doubt, be adopted by Austria, Bohemia and other neighbors of Germany. It will not interfere with the legitimate business of the electrical apparatus and equipment industry, nor will it do away with the many private stations and the old steam power equipment used in German factories. But it may lead finally to a centralization of all sources of primary power in the hand of the government.

Italy

One of the most promising countries in Europe for all forms of power development is Italy. Just now Italy struggles under the after effects of the war. Social unrest is rampant and the industry is rather disheartened. Italy today needs food and power. Coal has been lacking all through the war and the hydroelectrical power that was available has not served sufficient to supply the wants of its varied industries. So it is proposed now to extend, as much as possible, the large hydroelectrical sources of the country and to make them a true asset for the future industrial development. Although there is plenty of potential water power in Italy it is not always possible to make use of it without extensive preparations. This requires much capital which can not yet be found in Italy.

The electrical industry seems hardly large enough to handle the production of the enormous quantities of equipment that will be required to utilize even the most promising water powers. Outside help is expected and the American power industry no doubt will find a fertile field for enterprise in Italy as the German industry found it before the war. Of the more important projects for development may be mentioned one on the river Lire in the Lombardy evolving the production of 100,000 hp. These will be developed with the aid of four power stations each requiring the construction of a special dam. It is proposed to raise another 50,000 hp. approximately, by the erection of 3 plants in the Lombardy on the river Mera. In Tuscany where water power abounds, five different projects are under contemplation. The first of these is situated on the Merse. Here a dam of more than 60 yd. will be constructed and a power development of 8000 hp. is expected. Two plants are provided on the Serchio with a total production of 16,000 hp. From the Lima 2800 hp. can be taken.

The Tronto is already harnessed and a number of plants are in operation. These now will be extended by additional machinery and widening of the dam until 100,000 hp. in all can be obtained. A rather interesting development is proposed in the province of Campania on the Lake Matese. This provides for a double fall of 500 and 400 yd. approximately, by which two large power stations will generate 36,000 and 25,000 hp. On the river Mingardo in the same province a power station will be erected giving 6394 hp. and on the Bussento two stations will produce a minimum of 14,000 hp., approximately. Three large plants are to be located in the province of Abruzzi which has plenty of water falls. The three plants will be situated as follows: Two on the Sangro, and one on the Aventino. They will produce 29,800, 14,880 and 6000 hp. repsectively.

The most ambitious of the present undertakings seems to be that of the Sila in Calabria, where two large artificial lakes will have to be constructed, with a tunnel connecting them. Three large plants are to be built. A minimum power supply of 168,267 hp. is estimated but the machinery of the generating stations will have a capacity of 300,000 hp. It is estimated that Italy has 2,500,000 hp. of water power available in all. If the electrification of the railroads should be carried out this will require 1,000,000 hp. which still would leave 1,500,000 for industrial purposes. The power problem of Italy is very urgent and will have to be taken in hand immediately. Italy, for instance, has fair iron resources but the smelting has always proved expensive. With the help of electric smelting, the cost might be reduced to a point where the Italian iron mills could compete with the large foreign smelters which at present control most of the trade in Italy.

At Sarderello, natural steam is used very successfully for production and Italy possesses there today an electrical power plant operated by steam which is obtained by drilling holes in the ground. After a smaller installation had been erected during the year 1912, a big plant was put in operation during 1916 having a capacity of 7500 kw., and another unit producing 7000 kw. is to be added to the installation.

Power Progress in Spain

The great industrial development experienced by Spain during the war has made necessary a corresponding expansion of the supply of power. This has been obtained by adding to the steam power equipment, to the gas plants, and to the electrical power equipment. In Spain, the future of all forms of power development is undoubtedly very bright. Spain is one of the most active industrial countries of Europe and it has gained immensely in importance by the recent war, during which it supplied, not only most of the allies, but also took up again part of its former export trade to South America and other non-European markets.

In 1915, Spain had 2847 electrical power plants, most of which were situated in the province of Barcelona which holds the leading industrial regions of Spain. In Barcelona, a great number of factories of all kinds are situated, and the city itself is typical of the industrial cities of Spain. Barcelona, therefore, is also the biggest electrical power center, the large central station being an American enterprise and representative of the best America can give in this respect.

There were 80 hydroelectrical plants in Spain of over 800 hp. in 1918, producing 403,000 hp. of a potential hydroelectrical development of 974,000. Hydroelectrical development is now proceeding very fast in Spain and several additional 100,000 hp. of power will be in operation by the end of the present year. This work is mostly done by local capitalists but, with the example of the large Barcelona works to go by, there is no reason why American capital should not interest itself more fully in the electrical business of Spain. Spain is even less prepared industrially than Italy to sustain a large electrical development. The Spanish electrical industry is sound enough, but it lacks capacity for the manufacture

of the very powerful units which become more and more the rule in European electrical power development. It seems that the European electrical industry has come to the conclusion that only by using the biggest units can a supply of electrical energy be obtained cheap enough to withstand successfully the competition of other forms of power generation. Coal, of course, is rare in Spain although the peninsula has better resources at its disposal than Italy. Electrical power must no doubt play a large part in the coming industrial development of Spain.

A rather interesting feature in the plans of the Spanish government for the future employment of electrical power, is the electrification of part of the railroad system. This goes in line with similar plans all over Europe and is one of the outstanding tendencies of all electrical organizations of the old world. Conditions in Spain seem to be especially favorable for such a plan as the climate is mild and there is little danger of the system being interrupted by snow. So far no complete scheme of electrification has been put forward but the idea itself is uppermost in the mind of all power engineers and will no doubt come up for discussion very early.

With such a possibility ahead it seems that the American power industry should study conditions in Spain very carefully. The annual imports of electrical merchandise into Spain have been estimated at approximately $12,000,000 at pre-war prices. The business so far has been principally in the hands of German and English companies which either had manufacturing plants in Spain or were importing all of their goods from their home factories. It is claimed for the German importers of electrical goods that they knew their market well and introduced not only the class of products that were required but that they were always willing to accommodate a customer. When the war broke out, the German companies could not import directly from Germany. Having extensive connections in other countries, however, they continued their business for quite a while, buying from sources open to them, including the United States. With the progress of the war, German influence declined and the import trade is said now to be mostly in the hands of Spanish firms who in some cases are the agents of American concerns. Spain may need not only electrical equipment, but no doubt will also be a good customer for other power equipment, including boiler house equipment, steam generators, etc., for which there is always a fair demand in a country with an expanding industry.

Russia

Little can yet be expected from Russia. But given time to recover, and financial aid, the vast empire or what will take its place may form a source of power of almost miraculous extent. To quote from a report dealing with the Caucasus region only: The River Kura, between Tiflis and Puras has a fall of about 300 yd. that can give 300,000 hp. In the North Caucasus, the river Kuban can produce 175,000 hp., with another 45,000 somewhat lower on the stream. The streams of Georgia are estimated to have a total water power strength of 2,500,000 hp. during the summer and 4,000,000 during winter. Only little of all that possible power is developed, and the whole of Russia, is, in fact, still much behind as far as electrical power development is concerned. The principal cause of this backwardness is the climate. Many of the rivers that might be used for power generation freeze completely during the winter and are, therefore, useless for smaller development. Experience in the United States, however, has shown that given proper engineering protection large developments may be easily placed in winter bound regions and that it is only a matter of technique to overcome the dangers of ice. So the same might possibly be done in Russia, and with capital forthcoming, much can be expected from the opening of the Russian and Siberian water powers. There is much of natural riches hidden in this enormous country, and the supply of cheap power with the possibility of cheap heat and light would do much to bring it in the reach of the remaining world. It is to Russia, therefore, that the power engineers of Europe look at present for the great engineering enterprises of the future and it may fall to the lot of American engineers to do the work, as they, no doubt, have the ability and experience that will be required for the task.

Conditions are similar in Finland. There, also, electrical development has been slow and is bound to proceed at a slow pace until capital can be mobilized for the use of its industries. At the present moment, Finland finds much sympathy, but little real financial support. The country suffers from a depression of its exchange and, therefore, can not buy much foreign equipment.

Europe at present stands under the sign of centralizations. Small central stations are closed and interlocked with larger ones and with the increasing facilities for the construction of giant equipment there comes the desire for even bigger central stations. That much saving can be obtained in this manner there seems no doubt. It is estimated for instance that by the centralization of the leading English power stations in the Midlands, one city alone, Nottingham, will save approximately $1,000,000 on the cost of operating its tramways system. It is proposed in this case to erect a super power station on the Trent which will supply electrical power to an area of approximately 2000 sq. mi., including parts of the counties of Nottingham, Derby, Stafford and Leicester. The scheme will be completed in easy stages and $68,000,000 will be required to carry it through in all its parts. The size of this station and its general equipment is sufficient to stagger imagination. Nearly 100 acres of land will be required to place it and 1500 tons of coal will have to be supplied to it every day with an annual consumption of 580,000 tons of coal. The plant will be equipped with the most perfect machinery both for the generation of power and the handling of the supplies. The British scheme of development will make use both of coal generation and water power and it is proposed to build supply centers in the Scottish highlands, where large water powers can be made available.

"Honors that are easily gained are flimsy and not of lasting type. Reputation worth while entails struggle before and after it's won."

The Power Plant Repair Shop

An Outline of Equipment, Location and Arrangement for a Shop Particularly Suited to a Medium-Size Plant

IN PLANNING the power plant repair or workshop, there are several factors, which must be taken into consideration, and which to some extent affect the size and amount of equipment necessary. Among these are location, size and whether or not all repair work is to be handled. The location of a plant has much to do with the equipment necessary; industrial plants are usually provided with a machine shop to take care of all repair and maintenance work, including that for the power plant, but isolated plants, such as private or municipal lighting plants in small towns, either have to provide sufficient equipment, or depend on the local machine shop or garage for emergency machine work. Obviously, a large plant will require considerably more equipment than a small one under similar conditions. In any size plant, the installation of tools or machinery to handle at least part of the work will prove a good investment.

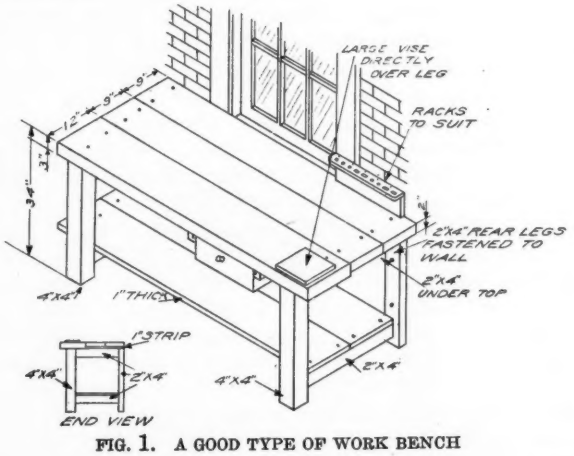


FIG. 1. A GOOD TYPE OF WORK BENCH

The equipment usually provided, ranges from a vise bench and hand tools in the smallest plants, to machine tools such as drill press and lathe in larger plants. Seldom, however, is a planer or shaper included.

Power plants may be roughly divided according to size into three classes: small, medium and large. In the smallest plants, the engineer usually does all the repair work within the capabilities of the facilities provided, which as a rule consist of hand tools and a vise bench. Machine tools are not often included.

In the medium-sized plant the equipment is generally more complete, comprising bench and hand tools, and quite frequently a lathe. Largest plants are, as a rule, supplied with all the above equipment, though of larger proportions, and occasionally a planer or shaper is included; and a regular force of machinists and helpers is employed to do repair work under the supervision of the engineer.

Equipment of the Shop

THERE ARE some tools which are necessary in any shop, and others which are more or less optional. It is, therefore, obviously impossible to make a rule for all cases. The following remarks will, therefore, apply principally to the medium-size and smaller plants.

The bench provided should be substantial, solidly fastened down. Figure 1 shows a good bench for general work. The top is best made of 3-in. thick maple as that is a material which will stand much abuse. This thickness applies only to the front for a depth of 12 in.; the back may be 2 in. or even 1 in. thick. A convenient width for the bench is 30 in. and the height should be from 32 to 34 in. The legs should be 4 by 4 in. in front and 2 by 4-in. in back with 2 by 4-in. cross pieces and 1 by 4-in. diagonal bracing. The bracing may be eliminated if the top is solidly fastened to the wall. The legs should be spaced about 4 or 5 ft. apart lengthwise. Cast-iron bench legs are also used to a great extent and are very rigid.

Two vises should be provided. The largest one should have 6 or 6½-in. jaws, and should be placed over one of the legs of the bench, to insure solidity. The small one may have 2½ or 3-in. jaws. Both should be provided with copper or lead jaws to prevent scoring of finished work by the hardened jaws. As a general rule the top of the vise should be at the height of a man's elbow; this may be taken as 42 in. on the average. If much heavy work is done, this height may be reduced, and for small work, it should be increased to obviate the necessity of stooping over the work. Drawers under the bench are a great convenience for small tools; but also a good gathering place for filings and dirt. Racks at the back of the bench are convenient for storing files, chisels, etc., where they are always within reach of the vise.

The hand tools should include several sizes of machinists' hammers, a sledge hammer, files of various grades and sizes and chisels for various classes of work. Straight shank drills up to ½ in. should be provided; larger drills should have Morse taper shanks. The largest size will depend on the work to be done, also on whether or not a drill press is available. The set should, however, run up to at least ¾ or 1 in. A set of hand reamers should be included, ranging from about ¼ or ⅜ in. to the largest size necessary. An "old man" and a ratchet drill form an irresistible combination for drilling the holes which frequently have to be drilled in awkward places. A breast drill will handle all the light work. Taps and dies should be provided to take care of the largest bolts or studs used. Provision of a small bench anvil removes the temptation to use the vise for an anvil, and materially lengthens the life of the latter.

Pipe cutting and threading tools and a pipe vise, to handle up to about 4-in. pipe, should be provided; it is not often necessary in repair work to handle a larger size pipe than this. The vise should be provided with a solid support similar to the work bench, though the top need be only large enough and sufficiently heavy to serve as a support for the pipe tools. Portable pipe supports are used to hold up the end of the pipe not supported by the vise.

A motor-driven grinder which carries the grinding wheel or wheels directly on the motor shaft is a good type. The wheels may be from 6 to 10 in. in diameter by 1 to 1½ in. thick. When machine tools are in use, however, a simple grinding head belt-driven from the counter-shaft will prove simpler and cheaper.

A small portable forge is useful and in most cases essential. In connection with this a hand or foot-operated blower is usually provided.

Drill presses are available in various styles and sizes. The type shown in Fig. 2 is a good one for medium work. For very heavy work the same general type provided with back gear and automatic feed will be found suitable. The 20-in. swing drill press shown provides for four speeds by shifting the belt. Two

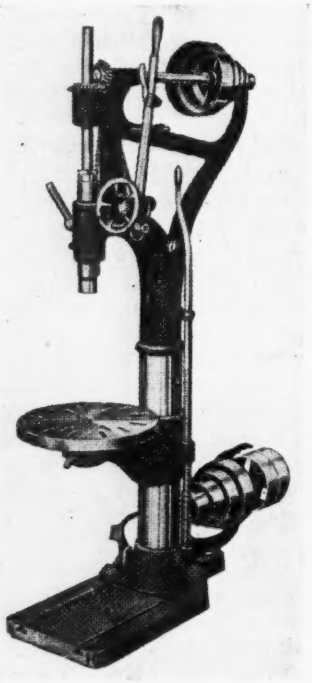


FIG. 2. A 20-IN. SWING DRILL PRESS

methods of feeding the drill are provided for by means of the lever shown or the hand-wheel immediately in front of it. Table adjustment is provided for by means of the long vertical screw to the right of the column.

The provision of No. 3 Morse taper socket allows holes up to 1¼ in. to be drilled; that is the largest size drill made with a No. 3 shank. Sleeves can be secured to reduce the size of the socket to hold drills with Nos. 1 and 2 Morse taper shanks, and for drills smaller than ½ in. a drill chuck should be provided with a shank to fit the socket in the spindle. In this particular drill press starting and stopping is accomplished by means of a foot-operated belt shifter.

In choosing the drill press, there are several desirable features to be looked for. Rigidity is one of them; the column and main casting should be amply heavy to bear the strains imposed on them. Another point is ample wearing surface in the bearings. Convenient arrangement of the operating mechanism is desirable. If an automatic feed is included the simpler it is the better, consistent with proper working; this applies to the back gear as well.

By far the most important tool and the one which requires the most care in its selection, is the lathe. There are many styles of lathes, some simple, and others with special fittings and movements of all sorts. It has been said that the lathe is the "king of tools" and when the versatility of the tool is considered the truth of that statement becomes evident. Besides the work for which it was designed, there are many milling jobs that can be done with comparatively simple fittings; key-ways can be cut without any extra fittings, and many small planing jobs can be done. As a drill press, its capacity is limited only by the size and weight of work which can conveniently be placed against the tailstock barrel.

The lathe chosen should be a screw-cutting engine lathe, and it may range in size from 12 or 14-in. swing in small plants to 20 or 24 in. in large plants. The average length of the bed for these sizes is from 6 to 10 ft. although greater lengths are made. Blocks are sometimes used for temporarily increasing the swing by raising the headstock, tailstock and toolpost. To insure accuracy such blocks, if fitted, should be purchased with the lathe, so that they may be fitted at the factory. The lathe itself should be one of rugged, heavy design, with plenty of iron in its bed and headstock. The bearings should be of generous proportions and contain efficient means of lubrication. Sometimes ring oilers are fitted, but more usually, medium-size lathes are fitted with simple bronze split bearings.

The carriage should be provided with a long bearing contact with the ways of the bed, and should be properly gibbed both in front and back. T slots should be provided in its upper surface for the purpose of bolting down work, for boring by means of a boring-bar mounted between centers. The cross slide should have automatic cross feed, actuated from a feed rod or a spline in the lead screw. A compound swivelling slide rest should be provided. The tailstock should be arranged to set over for taper turning. Hand wheels will be found much more convenient than machine handles on such parts as the tailstock feed screw and the carriage hand feed. Quick-change gears save time in changing gears for thread cutting, but are not necessary. Figure 3 shows a 14-in. swing lathe embodying most of, if not all, the desirable features mentioned.

The equipment furnished with the lathe, as a rule, consists of countershaft, hard and soft centers, complete set of change gears, at least two face-plates (one small and one large) and the necessary wrenches for tool-post, tailstock, etc. Chucks are not supplied, so they must be purchased separately. If only one chuck is to be had, it should be an independent four-jaw chuck; its size may be one-half the nominal swing of the lathe, or a little larger, say 7 or 8 in. for a 14-in. lathe. If two chucks are provided the second one may be a self-centering, geared scroll chuck, somewhat smaller than the independent chuck.

LOCATION OF THE SHOP

PROPER consideration should be given to the location of the shop. Good tools should not be placed in a damp basement or a dusty boiler room, with the expectation

that they will remain in good condition for any great length of time. In many cases it is possible to partition off one corner of the engine room, and no better place could be found, except a specially built shop.

The location should be chosen so as to secure good lighting by day; and for night work, good artificial illumination should be provided. Good lighting is required for the lathe, vise bench, and drill press in the order of their importance. Drill press work is, usually, relatively unimportant compared to lathe and bench work, and the drill press can therefore be discriminated against, to some extent, in the matter of lighting. The best type of light for bench or machine work, is one with a universal or semi-universal adjustment so that light may be secured where necessary.

In planning the layout of the shop the tools should be so arranged that the countershaft from which they are to be driven will not have to be unduly long. The grinder should occupy the most isolated position of all, in order to keep emery and grinding dust, as far as possible, from the lathe and drill press bearings. A suggestion for the arrangement of the shop is given in Fig. 4. The lathe, it will be noticed, is placed directly in front of a window. If this location is not available, the next best is somewhat to the left of the window, or with the tailstock end to the window and the bed projecting out into the room. Both of these positions allow the light to fall directly on the faceplate or chuck. Poor lighting will result from placing the machine to the right of the window.

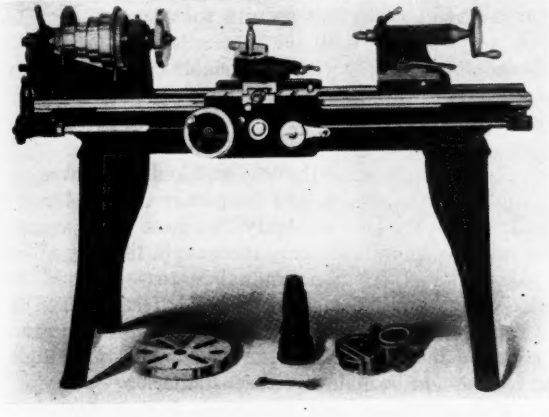


FIG. 3. A 14-IN. SWING BACK-GEARED SCREW-CUTTING LATHE

The large vise is shown to the right of the window, though it might have been to the left with equally good results. The object is to place it where good light can be secured on all sides of the work by swivelling the vise into various positions. Racks are shown at the back for the tools in common use, such as chisels, files, etc.

As a rule, drill press work requires hardly the accuracy of lathe work, and the drill press is therefore placed on the opposite side of the shop from the windows and the lathe. The grinder is shown, where it should be, at some distance from the lathe and drill press.

CARE OF THE TOOLS

GOOD TOOLS, if given proper attention and care, will last almost indefinitely. Small tools should be provided with special cabinets for their protection. Lathe tools and tool-holder bits can best be kept in portable racks or stands, somewhat similar to a drill stand, provided with holes in which the tools or bits can be stored in an upright position. A stand of this kind can be readily made of a block of wood of suitable size and the tool points are always in sight for selection of the proper shape.

The lathe requires careful attention. The bearings should be kept lubricated, and should be protected against emery, grit, and metal chips. If the oil cups or holes do not already have covers, they should be provided with them. For lubrication of the bearings, do not use engine oil. The proper combination is one of mineral oil and about 10 to 20 per cent of lard oil. Vegetable oils are sometimes used in place of animal oils (lard oil is one of the latter), but are more likely to gum. A heavy mineral grease should be used for the gears and lead screw; sometimes graphite is mixed with it.

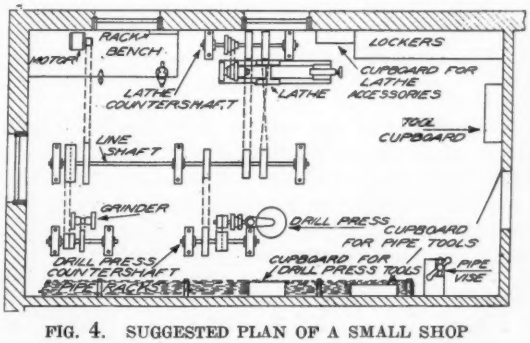


FIG. 4. SUGGESTED PLAN OF A SMALL SHOP

Wear of the ways of the bed can be reduced by fastening pieces of soft felt to the ends of the carriage, cut to fit, and in contact with, the vees, Fig. 5A. Grit is thus prevented from getting under the carriage and causing damage. The cross-feed screw on the carriage will, if not protected by an extension of the lower part of the slide rest, quickly be worn by the chips which fall around it. Protection if not provided can be secured by means of a copper, or other sheet metal, guard fastened to the end of the lower slide in such a manner as to cover the screw and vees. The screw for the upper slide is generally, if not always, well protected.

Wear in the headstock bearings is usually greatest in the upper brasses, as the tool has a tendency to lift the work and the spindle, and the belt also exerts an upward pull on the spindle. When play becomes perceptible, it should be eliminated by adjustment of the brasses. Neglect results in the bearings being worn to such an extent that difficulty may be encountered in properly alining the spindle with the tail stock. The spindle should be parallel to the bed, both vertically and horizontally.

Drill press bearings are usually provided with very long bearing surfaces, and as wear is concentrated on the ends of the bearings, generally the only provision for adjustment is collars to take up end play. Frequently ball thrust bearings are employed. Lubrication should not be neglected.

The grinder bearings can, if they are not already, be protected from emery and metal dust by means of

felt rings or a number of rings of heavy woolen cloth fastened to the ends of the bearings, and held in place by a sheet metal washer and screw, Fig. 5B. There may be some slight wear on the shaft due to the felt becoming charged with emery and acting as a polishing wheel, but there will be no wear in the bearings, due to emery or grit.

The countershaft bearings should be looked after, as well as the machinery, and should be oiled at regular intervals, the frequency depending upon the type of bearings employed, whether plain, wick oiling, or ring oiling.

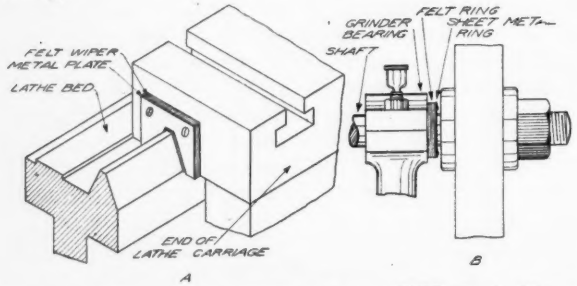


FIG. 5. METHODS OF MINIMIZING WEAR IN THE LATHE AND GRINDER

Care of any of the machinery or tools should in no way be slighted, and of the tools referred to, the lathe requires the most particular attention. The precautions described are ordinary, which if observed, will result in lowering the cost of repairs, and making accurate work possible and, not always least, easy.

How to Take Care of Stretch in Vertical Belts

By W. F. Schaphorst

VERTICAL belts give more trouble than others, because of the fact that as soon as the belt stretches, contact with the lower pulley is lost, and power will not be transmitted.

In the horizontal drive, stretch is easy to take care of, provided the belt is kept nice and soft and pliable with a treatment that penetrates, surrounds and lubricates every tiny fibre. It then becomes unnecessary to take up the horizontal drive at all. Many drives are in daily use. which have not been taken up for 18 yr. or more, and then they were taken up only because the belt became so slack that the slack side touched the tight side. Extreme slackness is as impracticable as extreme tightness.

Where vertical drives are used, it is obviously impractical to permit slack running because it is necessary continually to take up the belt stretch as the stretch occurs. One successful and economical method of constantly keeping vertical drives in pulling condition that has been brought to the writer's attention is to have a number of "fillers" or "inserts" in stock, already punched to match the belt and ready for insertion and lacing. Thus, for example, when a belt is put on new, it is cut short by an amount depending upon the distance between the shaft centers. The belt man uses his judgment as to what this short cut should be. Let us say that he desires to make it 7 in. He then selects a filler 7 in. long, of the same width as the new belt, and laces it into place, either with raw hide or wire lacing.

In a short time, the belt will stretch and will need taking up. The belt man then simply removes the 7-in. filler and replaces it with a 6-in. filler. After another week, say, he replaces the 6-in. filler with a 5-in. filler, and so on until all of the stretch, or most of it, is taken out of the belt.

The fillers can be kept in stock and used repeatedly. In this way, there is no loss of belting material due to taking up, nor is any time lost due to the punching of new holes, as they are already punched in the fillers.

The writer does not recommend this filler method for horizontal or sloping drive, because he is a believer in the slack drive, which gives maximum arc of contact between belt and pulley, least bearing friction, and highest efficiency.

Correct Boiler Feed Regulation

By N. G. Near

PREVIOUS to 1912, it was believed that the ideal boiler feed regulator should maintain an absolutely constant water level. All manufacturers of mechanical regulators strove to perfect such a regulator.

In 1912, however, one manufacturer revealed to the engineering world the first real example of boiler feed regulation—correct in theory and practical and dependable in operation.

The foremost power plant engineers in the United States have now swung around to this method. They now acknowledge that the water level should not be absolutely constant with a variable load, but that it should vary with the load, sometimes in direct proportion, and at other times in inverse proportion, depending upon conditions.

For example, when the load suddenly increases, there should be an automatic and temporary decrease in boiler feed. When the load suddenly decreases, there should be an automatic and temporary increase in the rate of boiler feed. When there is a gradual increase in load, there should be a gradual increase in boiler feed. When there is a gradual reduction in load, there should be a gradual reduction in feed. When the load is constant, the rate of feed should be maintained constant.

Modern boilers are so designed that considerable latitude is allowable in water level. All engineers of authority know this. There is a safe high level and there is a safe low level. The ideal regulator therefore takes advantage of this fact, and is set in such a way that it automatically prevents the water from rising higher than the safe high level, and prevents it from lowering lower than the safe low level.

The volume between these levels is utilized by the ideal regulator as a heat reservoir; that is, heat is stored automatically when there is a sudden decrease in load, and is automatically given off when there is a sudden increase in load. Some engineers call this the "condenser action." Other engineers call it a "heat flywheel." Whatever you may call it, it does the work—it stores heat—it gives off heat, saves boilers, saves fuel, saves piping, creates harmonious team operation in a battery of boilers.

BERNARD E. SUNNY

ACTIVE IN THE MANAGEMENT OF LARGE ENGINEERING AND FINANCIAL INSTITUTIONS. MADE HIS COMMERCIAL DEBUT AS TELEGRAPH OPERATOR. BY CLIFFORD ARRICK

IN THESE DAYS when it is possible to link wire and wireless telephone systems so that the human voice can perform one lap of its journey on a wire and the next lap through the air to its final destination, new electrical discoveries are commonly boiled down as news and placed on the next-to-the-last page of a newspaper, along with the lodge notices and obituaries. Remarkable strides in science do not astonish us any more. Ireland "calls up" Canada or Arlington talks to Paris, with Hawaii, like a curious "party-line" subscriber, "listening in."

Outstanding among the careers of those executives instrumental in popularizing and broadening the commercial field of the telephone is Bernard E. Sunny, president of the Chicago Telephone Co.

Born in Brooklyn 53 years ago, he spent his boyhood there and early became an expert telegrapher. When the Atlantic and Pacific Telegraph Co. opened its Chicago office, young Sunny was sent west as an operator, was soon made night manager and later manager of the Chicago office. Struck with the possibilities of Professor Alexander Graham Bell's telephone discovery, which received its first noteworthy demonstration at the Centennial Exposition in 1876, Mr. Sunny took up the study of the science and acquired a thorough working knowledge of the apparatus. His progress was so rapid that he was sought out by the Bell Telephone Co. and offered the superintendency of the Chicago enterprise, which he accepted, resigning his position with the telegraph company in 1879. When the Bell and Edison companies were merged into what is now the Chicago Telephone Co., he was retained as superintendent.

Mr. Sunny was one of the first to realize that with the development of the telephone business the number of wires and poles in the street would soon become not only a nuisance and an eyesore but an actual menace to property along the lines, as the maze of wires would hamper the fire department in its work. Storm damage to the wire system would also jeopardize the service if the wires were left suspended in the air. Eliminating these deterrent features was his early concern, and he was largely responsible for the first successful efforts to put in practice the system of underground wiring.

Mr. Sunny has never been one who could be charged with instability, but he is notably progressive, and in those early days electrical development was a fascinating study, and he was ever on the alert to promote new applications of the mysterious force. It was due to this characteristic that he decided to leave the telephone industry in 1888 and devote his energies to the development of the light and power field. Upon his entry into this branch of electrical work, he was chosen president of the Chicago Arc Light and Power Co. and was later called upon to act as western manager of the Thompson-Houston Electric Co. In the great merger which occurred some time afterward between the Thompson-Houston, the Brush and the Edison General Electric companies, Mr. Sunny was selected to look after the entire western business of the combined organizations. His responsibilities were great and the fate of vast capital was dependent upon his success or failure. History records that he measured up to the requirements of the situation in the fullest sense of the term.

After serving one year as a director of the Chicago World's Fair, Mr. Sunny declined re-election to devote virtually his entire time to the affairs of the Intramural Railway, of which he was the president. This was the pioneer third rail electric designed and constructed by Bion J. Arnold.

Though actively engaged in the exploitation of light and power undertakings, Mr. Sunny never lost interest in the telephone business, but kept constantly abreast of its wonderful improvement and expansion. While

active in the affairs of the General Electric Co. as vice-president in charge of its western interests, he was also a vice-president and director of the American Telephone and Telegraph Co. This connection, and the knowledge his associates had of his capacity as an organizer, led the officials of the big telephone system to turn to Mr. Sunny when affairs telephonic became disturbed in Chicago. The growth of the Chicago telephone system during and immediately following the late 90's had been enormous, and the demand continued in what appeared to be an overwhelming volume. There was grumbling on the part of the public that the company was not meeting the responsibilities resting upon it. Theodore N. Vail, who had himself but just returned to active participation in the affairs of the American Telephone and Telegraph Co. after an absence of 20 years, recognized the need of a man in Chicago who combined exceptional executive and organization ability, and he asked Mr. Sunny to return to telephone activity and help straighten out the Chicago situation. Mr. Sunny consented. This was in 1908, and the past 11 yr. his hand has been at the helm. His genius and energy have developed to the highest point of efficiency the tremendous telephone system that now serves Chicago, second only to that of New York, the greatest telephone system in the world.

Mr. Sunny is also president of the Michigan State, the Wisconsin and the Cleveland telephone companies.

There are few men engaged in the management of great corporate affairs whose careers have been filled with the activity that has marked that of Mr. Sunny. Not only has he been untiringly diligent in the electrical field, but in finance, in civics, in church and in humanitarian endeavor he has striven wisely and without flagging.

In Chicago his judgment is constantly sought by men of every class and calling. He is serving as a director of the Chicago City Railway, the Western Electric Co., the First National Bank and other corporations. He combines with wide knowledge and sound judgment a genial and kindly personality that makes him easily approachable and universally popular. His manner is quiet but cordial. He is capable of unusual concentration and his well-thought-out conclusions have their fruition in convictions which are courteously but firmly adhered to. Added to his other excellent qualities is that of unfailing optimism which keeps his head well above the rough seas of adversity that beset at times, thus enabling him to keep ever in view the sunlit goal of accomplishment.

Mr. Sunny, in 1878, married Miss Ellen C. Rhue, of Brooklyn, and their lives have been peculiarly happy and mutually helpful. At a dinner recently held in Mr. Sunny's honor, he took occasion to attribute to his wife's gentle and inspiring influence all the success that he had attained in life. Two children have been born of this union, Mrs. George B. McKibbin, of Chicago, and Arthur Sunny.

The Armour Institute of Technology conferred the degree of Doctor of Engineering on Mr. Sunny, June 4, 1908.

There has been no "secret of success" in the life of Bernard E. Sunny. Equipped with a mind capable of absorbing, retaining and applying knowledge, he has attacked each problem in life with the determination to solve it as nearly correctly as application and effort would permit. Superficial understanding meant and means nothing to him. The principle that underlies is the stone that must become the head of the corner, and he has consistently adhered to the motto of Davy Crockett, Be sure you are right, then go ahead.

Water-Tube Boilers for Wood Ships*

PART II. PRELIMINARY TESTS. BY HENRY KREISINGER

THIS part of the paper presents some of the results of special investigations conducted by the Fuel Section of the Bureau of Mines in connection with the tests of the three-pass and four-pass marine boilers shown in Figs. 1 and 2 of Part I. Outline diagrams illustrating the methods of testing these boilers are given in Figs. 3 and 4 herewith. The special investigation consisted of the study of combustion in the furnaces and the temperature of gases as they flow through the boiler.

The study of combustion was carried on by the analysis of samples of furnace gases collected at various points in the setting.

Figure 3 is a diagram of the three-pass boiler as originally designed. After the first few tests the baffles were extended, making smaller the gas passages between the ends of the baffles and the water legs, as indicated in Fig. 7. Other changes were also made as the investigation indicated the need for them. The points at which gas samples were collected are indicated by the small circles designated by the capital letters *A*, *A'*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, and *I*.

During the first six tests a large amount of combustible gas passed out of the furnace and either burned at the base of the stack, causing high flue-gas temperature, or escaped unburned. It was apparent that not enough air was admitted over the fuel bed, and that the air which did find its way into the furnace through the firing door was not sufficiently mixed with the combustible gases to cause them to burn completely in the furnace.

Some of the air admitted into the furnace through the firing door found its way out of the furnace through the opening at *I*, between the first baffle and the front water leg, as indicated by the arrow in Fig. 3. A large part of the air also passed around the end of the first baffle without mixing thoroughly with the combustible gases rising from the fuel bed. As the gases and air passed through the boiler they formed a better mixture which tended to burn at the base of the stack. Evidently the combustion space was too small and the path of the gases and the air through the furnace too short for the two to form an intimate mixture.

* From paper presented before the American Society of Mechanical Engineers.

Admission of Air Over Fuel Bed

It was apparent that more air had to be admitted over the fuel bed, and better means provided for mixing it with the combustible. It is a proven fact that in a hand-fired furnace, when the fuel bed is level and 5 in. thick, no free oxygen can be forced through it, no matter what air pressure is used in the ashpit. The gases rising from the fuel bed contain practically no free oxygen and a large percentage of combustible gas. It is true that if the fuel bed contains holes or thin spots, air passes through them; however, admission of air through the holes in the fire is undesirable because the size of holes cannot be controlled. The holes are large before firing, when small quantity of air is needed over the fuel bed, and are nearly absent immediately after firing, when large quantity of air is needed to burn the volatile matter from the freshly fired coal. It is therefore much better to admit air over the fuel bed through special openings in the firing door or a bridge wall. The quantity of air admitted through such openings is nearly constant and can be controlled more easily. The air should be supplied in a large number of small jets and as close to the fuel bed as practicable, so that as much as possible of the combustion space above the fuel bed is utilized for mixing and combustion.

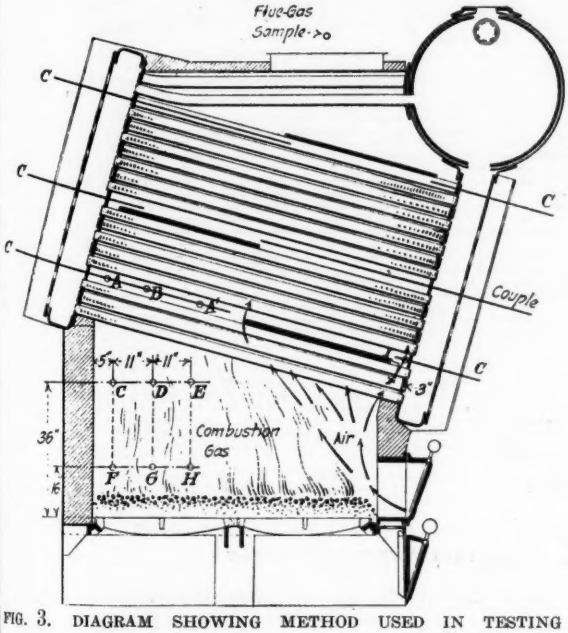


FIG. 3. DIAGRAM SHOWING METHOD USED IN TESTING THREE-PASS TYPE OF BOILER

Following these principles a number of ½-in. holes were made in each firing door; the small opening in the first baffle at *I* was closed and the baffle extended, making the gas passage between the end of baffle and the rear water leg 36 in. This had the effect of causing the air admitted through the firing door to flow farther to the rear of the furnace and facilitate better mixing with the combustible gases. In addition to these changes, Wager's bridge wall was installed to supply additional air to the rear part of the furnace. The method of installing Wager's bridge wall is shown in Fig. 4. The bridge wall consists of a large number of cast-iron bars placed against the rear wall of the furnace, and forms a structure similar to a plain grate. The air passes into the furnace through narrow slots between the bars, and is regulated by the thickness of the fuel bed near the bridge wall. The thicker the fuel bed, the greater is the area of the air spaces covered with coal, and the smaller is the quantity of air flowing into the furnace. The air enters in a large number of thin streams.

With the air admitted through the firing door and through the bridge wall, the combustible gases rising from the fuel bed are squeezed between two streams of air coming in from two different directions and the mixing is greatly aided. The direction of the streams

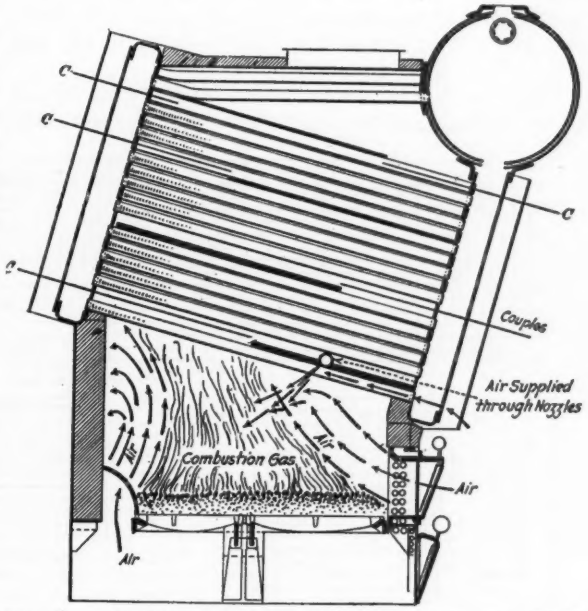


FIG. 4. DIAGRAM SHOWING FOUR-PASS TYPE OF BOILER WITH FACILITIES FOR INTRODUCING AIR OVER FUEL BED

of air admitted over the fuel bed under these conditions is indicated in Fig. 4.

Openings for Admitting Air Over Fuel Bed

In the front of the furnace there were a total of 240 half-inch holes located in the fire doors, the cast-iron arches over the doors, and the cast-iron columns supporting the arches. The total area of these holes is about 48 sq. in. In addition to this there was a space of ⅛ to ¼ in. wide, amounting to about another 48 sq. in., between the door frames and the fire doors.

In the Wager bridge wall the open spaces between two bars were about 3/16 in. wide and 3 in. high. The bars were spaced about 1¼ in. center to center, making the total area in the bridge wall about 64 sq. in. The total area for admission of air over fuel bed was then about 160 in. This opening is approximately 2 per cent of the grate area.

Mixing of Air and Combustible by Different Methods of Admitting Air Over Fuel Bed

In order to determine the effect on the mixing and combustion of various methods of admitting air over the fuel bed, a set of six gas samples was taken in the furnace and two in the gas passage between the rear

water leg and the end of the first baffle. The points at which these samples were taken are indicated in Fig. 3 by the small circles designated by the capital letters *A* to *H*. The analyses of these samples are shown graphically in Fig. 5.

Figure 5 shows five groups of tests, each group being represented by one of the five vertical charts. The furnace conditions under which each group of test was made are indicated by the label at the foot of each chart. Each of the squares in each vertical chart gives the samples taken at one elevation above the grate. Thus, the lowest square gives the analyses of samples taken 16 in. above the grate; the middle square gives the analyses of the samples taken 36 in. above the grate, and the highest square the samples taken in the first pass.

The abscissas of the lower two squares give the distance of sampling from the rear of the furnace wall; and those of the highest square give the distance of the point of sampling from the rear water leg. The ordinates give the percentage of the gases. The points giving the percentage of each gas at one elevation above the grate are connected by a smooth curve, principally to make the chart clearer. The analysis of the flue gases collected at the same time at the base of the stack is given in the small tables in the top squares. The location where the stack gases were taken is also indicated in Fig. 3.

The first group of tests gives the analysis of the furnace gases when the air over fuel bed was admitted through the firing door and through Wager's bridge wall. The chart is intended to show how the air admitted through the bridge wall mixes with the gases and affects combustion. The sample taken 16 in. above the grate and 5 in. from the rear wall shows practically no combustible gas, over 10 per cent of free oxygen, and about 9 per cent CO_2. The sample taken 27 in. from the rear wall shows about 7½ per cent of combustible, only 2½ per cent of oxygen, and nearly 13 per cent of CO_2. Apparently at this level the oxygen admitted through the bridge wall did not have a chance to penetrate far enough toward the center of the furnace to help in the combustion. The sample taken 36 in. above the grate and 5 in. from the rear wall shows less than 8 per cent of oxygen, a trace of combustible gas, and nearly 11 per cent CO_2. At this elevation above the grate the sample taken 27 in. from the rear wall shows less than 4 per cent combustible gas, about 3 per cent of oxygen, and nearly 13 per cent of CO_2. Comparison of the analyses of samples taken at these two elevations indicates that the air admitted through the bridge wall, in rising about 2 ft., has penetrated to a considerable depth into the stream of combustible gases rising from the fuel bed.

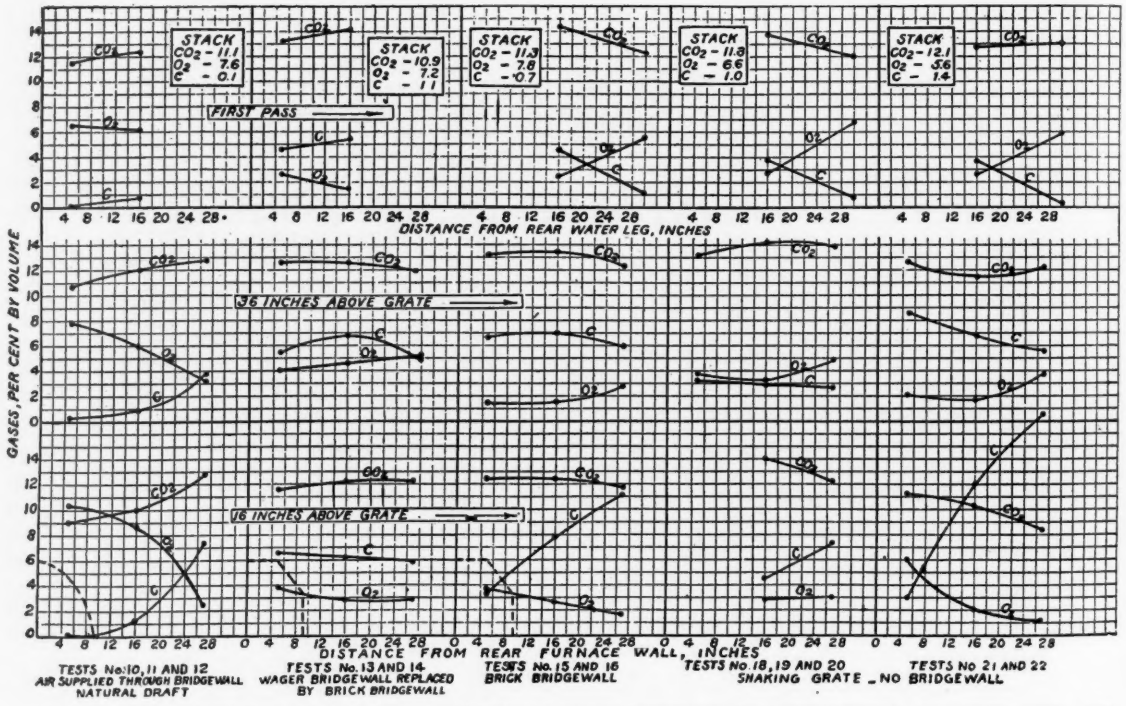

STACK CO2 - 11.1 O2 - 7.6 C - 0.1
STACK CO2 - 10.9 O2 - 7.2 C - 1.1
STACK CO2 - 11.3 O2 - 7.8 C - 0.7
STACK CO2 - 11.8 O2 - 6.6 C - 1.0
STACK CO2 - 12.1 O2 - 5.6 C - 1.4
FIRST PASS
36 INCHES ABOVE GRATE
16 INCHES ABOVE GRATE
GASES, PER CENT BY VOLUME
DISTANCE FROM REAR WATER LEG, INCHES
DISTANCE FROM REAR FURNACE WALL, INCHES
TESTS No.10, 11 AND 12 AIR SUPPLIED THROUGH BRIDGEWALL NATURAL DRAFT
TESTS No.13 AND 14 WAGER BRIDGEWALL REPLACED BY BRICK BRIDGEWALL
TESTS No.15 AND 16 BRICK BRIDGEWALL
TESTS No.18, 19 AND 20 SHAKING GRATE
TESTS No 21 AND 22 NO BRIDGEWALL

FIG. 5. COMPOSITION OF GASES IN FURNACE WITH VARIOUS METHODS OF INTRODUCING AIR OVER FUEL BED AND THE EFFECTIVENESS OF MIXING. THREE-PASS WATER-TUBE BOILER

In the first pass the composition of the gases in the first 16 in. from the rear wall is nearly uniform, showing that the air admitted through the bridge wall mixed well with the combustible gases and did not pass out of the furnace in a separate stream. The stack gases showed, at the same time, 11.1 per cent CO_2 and only 0.1 per cent combustible, indicating a good combustion.

The second and third vertical charts give the analyses of gases of two groups of tests made with Wager's bridge wall replaced by a brick wall of similar shape but having no provision for air admission. The shape of this brick bridge wall is shown by the dotted lines in the lower left-hand corners of the lowest squares. In both of these groups of tests the percentage of oxygen in

the samples taken in the furnace is low and the percentage of combustible gases is high, clearly indicating the lack of sufficient air supply. The stack gases of these two groups of tests contain a considerable amount of combustible, although the percentage of free oxygen is about the same as it was in the groups of tests made with Wager's bridge wall. Although the air found its way into the furnace, it was not introduced close enough to the fuel bed to bring the combustion nearly to completion before the gases left the furnace. In the second group of tests the gases passed out of the furnace still containing about 5 per cent of combustible, and in the third group they contained 3 per cent of combustible gas. It should be noted, however, that in the third group of tests the samples collected in the first pass were taken farther away from the rear wall, and their analyses show the presence of the air admitted through the firing doors, the sample taken 30 in. from the rear water leg showing more free oxygen than the sample taken only 16 in. from it.

The tests of the fourth and fifth groups were made with a shaking grate and no bridge wall of any description. The samples taken 16 in. above the grate indicate that a small quantity of air passed into the furnace close to the rear wall, but it was not sufficient to have much effect on the combustion. The percentage of combustible remained high, even when the gases reached the first pass. In these two groups of tests the samples taken in the first pass 30 in. from the rear water leg show the effect of the air admitted through the firing door. The stack samples show over one per cent of combustible gas and lower oxygen than either of the three previous groups. The lack of proper admission of air over the fuel bed is clearly indicated in these last two groups of tests. The advantage of air admission through Wager's bridge wall was clearly demonstrated and was therefore used on all subsequent tests with hand-fired furnaces.

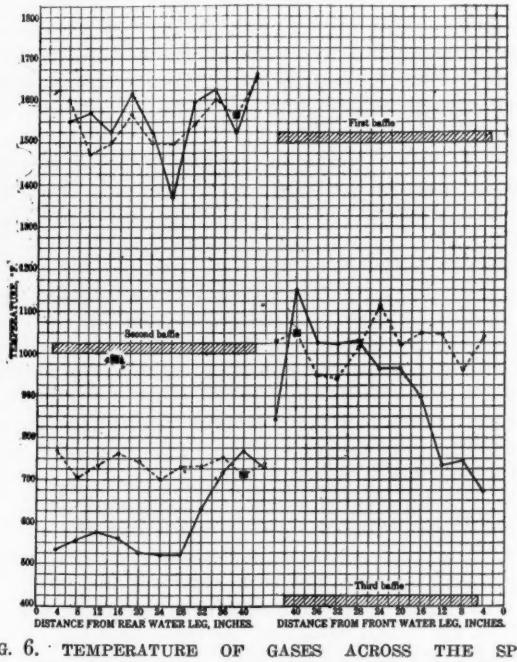


FIG. 6. TEMPERATURE OF GASES ACROSS THE SPACE BETWEEN THE END OF BAFFLES AND THE WATER LEGS. THREE-PASS BOILER, SHORT BAFFLES

Effect on Combustion of Different Methods of Admitting Air Over Fuel Bed

In a similar way, the effect on combustion of various methods of admitting air over the fuel bed was shown by means of tests made on the four-pass standard boiler illustrated in Fig. 4. The samples were taken similarly to those on the test with the three-pass boiler, the points at which they were taken being also indicated by the abscissæ and label in each square.

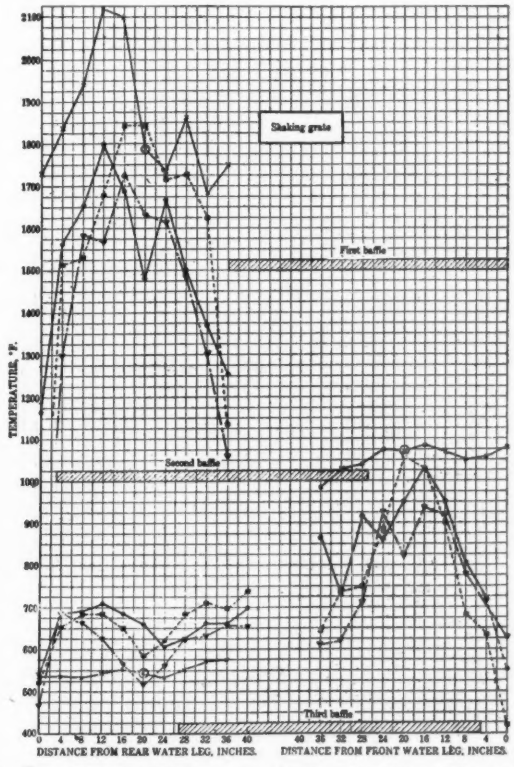


FIG. 7. TEMPERATURE OF GASES ACROSS THE SPACE BETWEEN THE ENDS OF BAFFLES AND THE WATER LEGS. THREE-PASS BOILER, LONG BAFFLES

The first group of tests was made with the air supplied over the fuel bed, through the firing door, and through Wager's bridge wall. Sixteen inches above the grate, the admission of air through the bridge wall was apparent only in the sample taken 5 in. from the rear wall. Samples taken 36 in. above the grate and in the first pass indicated fairly uniform distribution of the air but an insufficient quantity of it. Apparently, during these tests the fuel bed near the bridge wall was carried too thick. Had a thinner fuel bed been carried, the combustible in the first pass would have been much lower.

The second group of tests was made with the air over fuel bed being supplied with natural draft, through Wager's bridge wall, and through the firing doors, and in addition to this also under pressure of 2 in. of water through 17 half-inch nozzles from a 3½-in. pipe placed between the first and second rows of tubes, as indicated in Fig. 4. The object of the air forced in through these

nozzles was to force the air supplied through the firing door into the center of the stream of combustible gas rising from the fuel bed and cause intimate mixing. The action of these nozzles is shown in Fig. 4. The samples collected in the first pass showed fairly uniform mixture and lower percentage of combustible than was obtained when the air was admitted only through the bridge wall and through the firing door. However, the amount of combustible was a little too high, indicating that not quite enough air was admitted.

The third group of tests was made with air admitted through the firing door, and with natural draft and air admitted through Wager's bridge wall under a pressure of $\frac{3}{8}$ in. of water. In this case the air admitted through the bridge wall tended to flow in a separate stream close to the rear wall without penetrating very

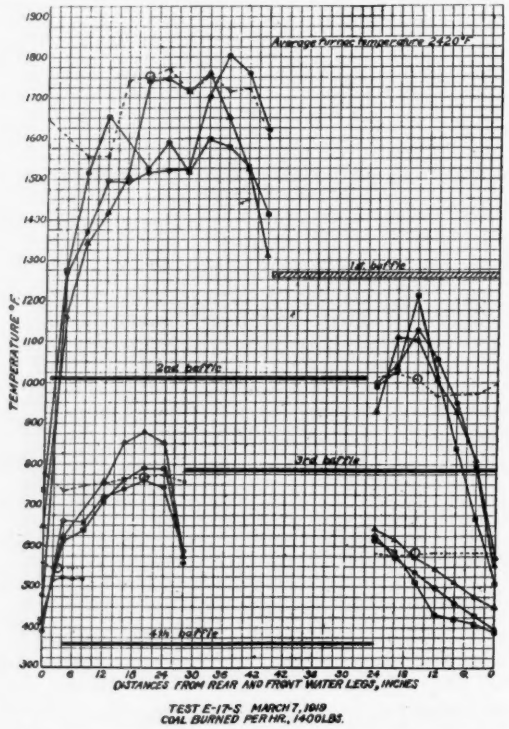


FIG. 8. TEMPERATURE OF GASES ACROSS THE SPACE BETWEEN THE ENDS OF BAFFLES AND THE WATER LEGS. FOUR-PASS BOILER, FOUR LONG BAFFLES

deep into the stream of combustible gas. The analyses of the samples taken in the first pass showed that the excess of air decreases as the distance from the rear water leg increases. On the whole, the admission of air through the bridge wall under pressure proved to be undesirable in this type of furnace. The tests represented by the second group showed conditions most favorable to complete combustion. However, the installation of the nozzles entails undesirable complications in boiler plants of ships. The conditions represented by the first group recommend themselves by their simplicity and effectiveness when attention is given to the proper thickness of fuel bed next to the bridge wall.

Temperature Measurements

The temperatures were measured with thermocouples inserted into the setting through the hollow staybolts and moved across the gas passages, as indicated by the straight lines labeled "couples," or *C*, in Figs. 3 and 4. The temperatures were measured across the spaces between the ends of the baffles and the water legs. These spaces are called in this paper the first, second, third, and fourth pass, respectively, counting from the lowest baffle up.

Results of Temperature Measurements on Three-Pass Boiler

Figure 6 shows graphically the results of such temperature measurements made on Test No. 2, which was made on the three-pass boiler with the original arrangement of the baffle. The length and the position of the baffles with respect to the water legs are indicated in the figure. The dotted line shows the variation of temperature due to varying furnace condition and the solid line gives the temperature due to different position of the moving couples. In order to obtain approximately the correct reading of the moving couple in each position, allowance must be made for the varying temperature due to furnace conditions. Because the temperatures of the first pass are the highest, they are placed at the top of the chart; and similarly, because the temperatures in the third pass are the lowest, they are placed at the bottom of the chart. Therefore, in studying these charts, it should be kept in mind that the flow of gases would be represented thereon from the top to the bottom.

The first pass shows no regular variation in temperature due to position of moving couple. This indicates that the distribution of the hot gases through this pass is fairly uniform. The second gas, however, shows the highest temperature one foot from the end of the baffle and the temperature drops down rapidly each side of this point. This seems to indicate that a large part of the hot gases pass through the space between 6 in. to 24 in. from the end of the baffle. The remaining space of about 24 in., next to the front water leg, contains only slowly moving and comparatively cool gases. The same condition exists in the first pass, most of the hot gases passing through the 18-in. space next to the end of the third baffle, the remaining 28 in. of the third pass being practically unused by the moving gases. The slight elevation in the temperature at a distance of 12 in. from the rear water leg is very likely due to hot gases passing through the narrow space left between the second baffle and the rear water leg. These temperature measurements show the desirability of increasing the length of the second and third baffles and thus cause the hot gases to pass over the greater part of the heating surface of the boiler. Although the temperature measurements do not show the desirability of increasing the length of the first baffle, nevertheless the baffle was made 10 in. longer after the first six tests. Lengthening the first baffle had the tendency to bring the air admitted over the fuel bed through the firing door farther into the stream of combustible gases rising from the fuel bed and thus aid in their combustion.

Figure 7 gives the temperature measurements on one of the tests made after the baffles of the three-pass boiler were lengthened. In this test three moving couples and one stationary couple were used in each pass. The temperatures obtained by the stationary couple are

represented by the line connecting the points indicated by small crosses. One of the moving couples was placed in the center of the boiler and the other two about 18 in. from each side wall of the boiler. With these longer baffles the hot gases more nearly fill the passage left between the end of the baffle and the water legs. Considerable variation is also shown by the three moving couples, indicating that on one side of the boiler the gases may be hotter than on the other, which fact can be expected with such a wide and shallow furnace. The fuel bed on one side of the furnace might be in different condition than the fuel bed on the other. Owing to the short distance from the fuel bed to the boiler the gases have little chance to mix and equalize the temperature.

Figure 7 also indicates that it is very difficult to tell what the temperature is in any one pass by making temperature measurements with only one stationary couple. Such measurements may be hundreds of degrees higher or lower than the average temperature in the pass.

Temperature Measurements on Four-pass Boiler

Figure 8 shows similar measurements on the four-pass boiler. In this case three moving couples and one

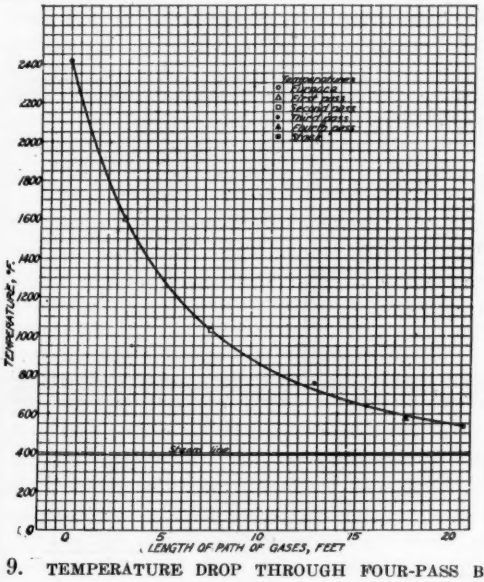


FIG. 9. TEMPERATURE DROP THROUGH FOUR-PASS BOILER

stationary couple are used in each pass. The position of the stationary couple is indicated by the small circle, and the temperatures indicated by the couple are shown by the dotted line. These temperature measurements indicate that in the second, third, and fourth passes a large part of the stream of hot gases passes within the narrow space at the end of the baffle. The little hump in the curves in the third pass near the rear water leg is very likely due to some of the hot gases passing through the small space between the second baffle and the rear water leg. These gases pass up close to the rear water leg and cause a somewhat higher temperature.

Figure 9 shows the average temperature drop of the gases along their path of travel through the four-pass water-tube boiler. The points on these curves have been obtained by averaging the points in the stream of gas in Fig. 8. The abscissas of the chart are the approximate length of the path of gases through the boiler, measured from the point where they enter among the lowest row of boiler tubes.

Characteristics of Linemen's Gloves

SOME day when you are walking along a "main traveled" road where traffic is piled back as far as one can see and linemen are repairing a broken wire, stop and watch them work. They are interesting artisans —the most interesting phase of their operations you will not see. The gloves they wear tell a unique story. Probably the line they are handling is "alive" and carrying electric current at a voltage high enough to cause instant death; yet they pick it up, twist it, splice it as nonchalantly as though handling fishing tackle. They are able to pick up the live wire because of the rubber gloves they wear. Did you know that these gloves are today made according to rigid specifications completely standardized and that no purchasing agent dare buy rubber gloves until he has thoroughly tested them?

No glove can be marked with the manufacturer's name or with the size in such a manner as to injure it in any way. Every glove must be more than 14 in. long and the average thickness not less than 60 mils. They must have a tensile strength of 1200 lb. per square inch and bear having 2 in. of their surface stretched to 12 without a rupture. The gloves shall be capable of withstanding the application of 18,000 v. without puncturing.

The dielectric test is made by immersing the glove in a pan of water with the glove nearly full of water. The water inside and outside of the glove forms the electrodes. These are conveniently connected to the testing transformer by means of a chain suspended within the glove and by direct connection to the retaining vessel.

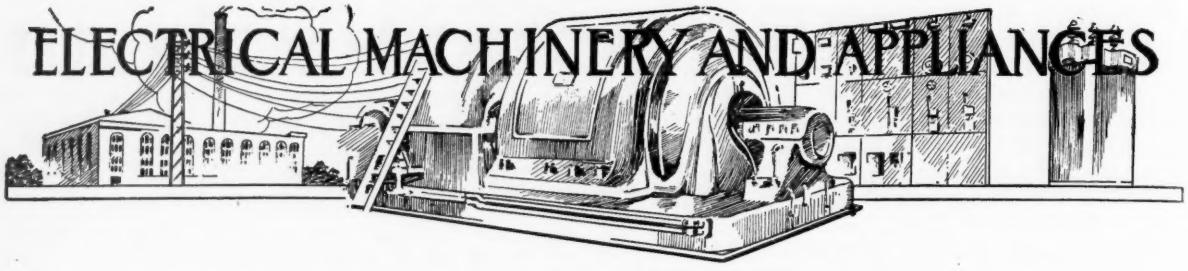
After the gloves are purchased, rigid inspection is insisted upon; they are subjected to periodic high voltage tests weekly or monthly, cleaned with soap and water and stored in cold, dark places. They are marked by serial numbers and their history is kept.

You understand that should one of the linemen you have been watching puncture his gloves, death may result. The perfection of linemen's rubber gloves is one of the silent romances of the electrical industry. They are as important in the day's work as the steel helmet in battle. Today linework is a hundred times safer than formerly, for now, when a line is deadened, the switch is usually of the modern safety enclosed type, and no other person except the man on the line holds the key that locks the disconnected switch.

U. S. Civil Service Commission announces that the Government is in need of a large number of draftsmen of various kinds. It is stated that fully 1000 draftsmen were appointed in the Government service during the last calendar year. During this period of reconstruction, technical men are especially needed. Besides draftsmen, there are openings for surveyors and computers, also assistant and associate engineers, electrical, mechanical, civil, chemical, and ceramic.

Further information and application blanks may be obtained from the secretary of the U. S. Civil Service Board at Boston, New York, Philadelphia, Atlanta, Cincinnati, Chicago, St. Paul, St. Louis, New Orleans, Seattle, or San Francisco, or from the U. S. Civil Service Commission, Washington, D. C.

ELECTRICAL MACHINERY AND APPLIANCES



A Study of Dynamo Electrical Machinery---XII

CHARACTERISTICS OF THREE-PHASE MACHINES; INSTALLATION OF ALTERNATING-CURRENT GENERATOR. BY OTTOMAR H. HENSCHEL

WITH the more general use of alternating current, especially so for power service, long-distance transmission systems and more extensive distribution systems became necessary. Economy of construction was, however, of vital importance and as a considerably larger amount of copper (and also line of fittings as cross arms, brackets, insulators, insulator pipes, etc.) was required to transmit a given amount of power over a four-wire two-phase system than over a three-wire three-phase system, the latter proved more desirable and as a result, the three-phase alternating-current generator rapidly displaced the two-phase machine.

Let E represent the voltage across any two lines at the receiving end of either a two-phase or a three-phase system; R_2 the resistance of each of the four wires of a two-phase system; and I_2 the current flow in amperes in any one line of a two-phase system. The power in watts is then equal to $2EI_2$ while the line loss in watts may be represented by $4R_2I_2^2$.

With I_3 and R_3 designating respectively the current flow in amperes and the resistance in ohms of a three-phase system delivering the same amount of power as the two-phase this power expressed in watts is equal to $\sqrt{3}\ EI_3$ (assuming unity power factor in each case) and the loss in watts to $3R_3I_3^2$. $\sqrt{3}\ EI_3$ is, however, equal to $2EI_2$ or, cancelling E from each side of the equation, I_2 is equal to $\sqrt{3}\ I_3 \div 2$.

The power losses are also equal or $4R_2I_2^2 = 3R_3I_3^2$; but, as I_2 is equal to $\sqrt{3}\ I_3 \div 2$ we have

$$4R_2\left(\frac{\sqrt{3}\ I_3}{2}\right)^2 = 3R_3I_3^2$$

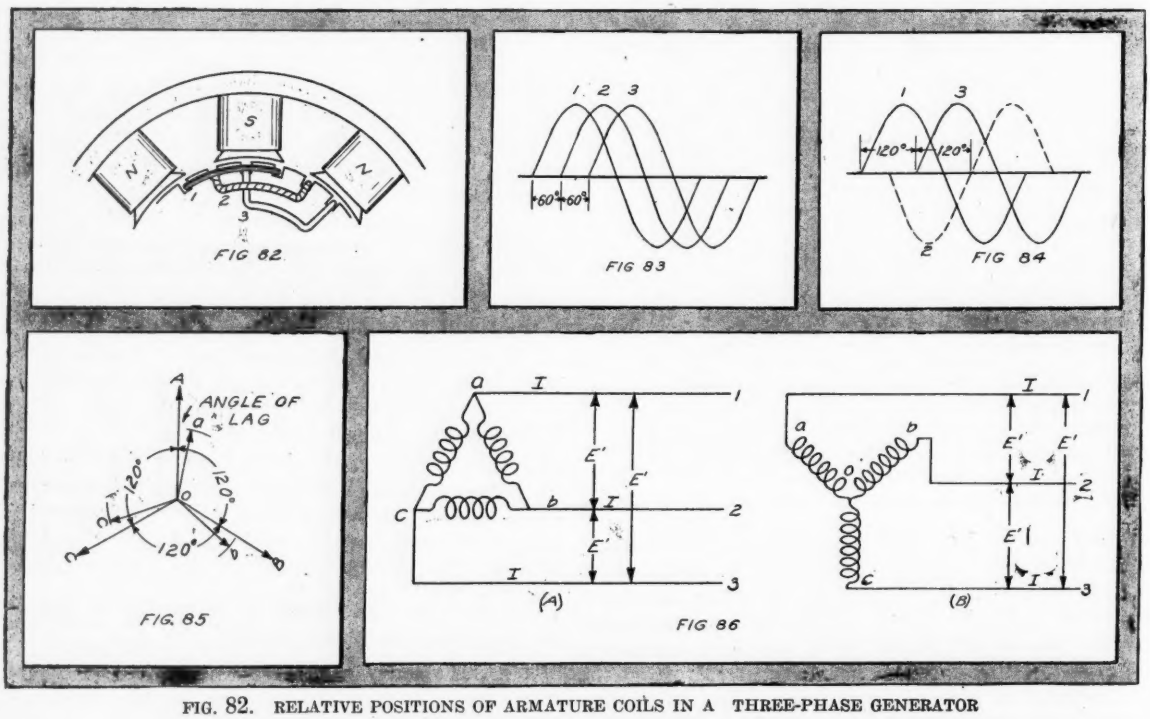


FIG. 82. RELATIVE POSITIONS OF ARMATURE COILS IN A THREE-PHASE GENERATOR

FIG. 83. INTERNAL ELECTROMOTIVE FORCE CURVES OF A THREE-PHASE GENERATOR

FIG. 84. ELECTROMOTIVE FORCE CURVE DUE TO PHASE WINDING 2 CONNECTION REVERSED

FIG. 85. ELECTROMOTIVE FORCE AND CURRENT RELATIONS OF A THREE-PHASE GENERATOR

FIG. 86. ILLUSTRATING DELTA OR MESH AND Y OR STAR ARMATURE WINDING CONNECTIONS

a formula which upon simplification resolves itself into the form $R_2 = R_3$, thus revealing the fact that the wires of each system have like resistances and are of the same weight. It is therefore apparent that with a given amount of delivered power the two-phase system requires 4/3 times as much copper as the three-phase. In other words, the copper cost of a three-phase system is 75 per cent of that of a two-phase system.

Three-Phase Generators

Let us assume Fig. 82 to represent part of the field structure of an alternating current generator together with a section of the armature and its windings, consisting of coils 1, 2 and 3 joined to other members of like sets and terminating in three collector rings. Each of the armature coils, as may be seen by reference to Fig. 82, is placed in slots so spaced as to bridge the polar pitch of the machine, that is, when the center line of any one coil coincides with the center of any pole piece the center line of the other side of the coil will coincide with the center of the adjacent pole piece. Between the slots of any given coil, however, are two other equally spaced slots each carrying other coils so that, as the armature revolves, coils 1, 2 and 3 pass successively under the pole pieces with the result that electromotive forces are induced within the windings which, due to the relative positions of the coils with reference to each other, are displaced as shown in Fig. 83 by 60 electrical degrees.

With this arrangement, however, it is evident that like electromotive force (and current) values occur at irregular periods, a condition not conducive to the satisfactory operation of many kinds of current consuming devices. In order to overcome this, it is usual therefore to reverse the terminal connections of phase 2 thus reversing the phase of its electromotive force with respect to the load and obtaining a set of electromotive force curves as shown in Fig. 84, corresponding values of which are at all times displaced by 120 electrical degrees. This displacement of electromotive force curves exists, however, only outside of the machine; within the machine, it is shown in Fig. 83.

As a rule, winding connections are made within the generator and but three leads brought to the terminal board. In making these internal connections, one of two schemes may be employed: they may be either of the delta or mesh form as shown at A, Fig. 86, or of the Y or star form, B Fig. 86.

With either form of winding, the electromotive force and current relations may be shown vectorially, as shown in Fig. 85, wherein vectors OA, OB and OC, each 120 deg. apart, represent electromotive force values while vectors Oa, Ob and Oc, shown lagging behind OA, OB and OC, represent current values. The degree of angle of lag (or lead when capacity predominates) is dependent upon the power factor; with unity power factor, Oa coincides with OA, Ob with OB and Oc with OC.

While in the delta scheme of connections, the voltage across the mains, E′, as indicated at A, Fig. 86, is identical to the phase voltage that is equal to that across windings ab, bc or ca, such is not the case where the Y system is employed. Voltage E′ across any two lines, B Fig. 86, is not the same as that across any winding as oa, ob or oc, but instead, where the voltage across any one of these windings may be designated by e, E′ is equal to $e\sqrt{3}$. This is due to the fact that E′ is equal to the difference between the voltages of any two windings as for example, line voltage E′ across mains 2 and 3 is equal to the difference between voltages across ob and oc.

In this scheme, however, the line current I is equal to the phase current, that is the current flow through any winding. With the delta connection, because of the fact that the current flow through any line is at any instant equal to the difference between the current flow through any two windings, the line current I is equal to $i\sqrt{3}$ where i is the current flow in amperes through any one winding.

Where e and i represent the volts and amperes of each armature phase respectively, it is evident that in each case the power in watts is equal to e i p. f. where p. f. is the power factor expressed as a decimal. But, in the Y connected armature, E′ is equal to $e\sqrt{3}$ and i is equal to I while in the delta scheme, I is equal to $i\sqrt{3}$ and E′ to e. As a consequence, the power in watts may be represented by the equation $W = \sqrt{3}$ EI p. f. where W represents the number of watts.

Installation of Alternators

Relative to the erection of belted types of alternating-current generators, Westinghouse publications offer the following suggestions:

(1) Set the frame in position, level it, and insert the bearings, if they are separately shipped. If the generator has a split frame, follow the same procedure with the lower half frame.

(2) See that the bearings and oil reservoirs are clean and free from dirt. Place the rotating part in its bearings.

(3) Clean the contact surfaces of both halves of the frame, dressing down the burrs and rough edges to insure a perfect magnetic joint. If split frame, set the upper half in position and secure to the lower half by the field bolts and feather keys.

(4) Accurately aline the shaft of the generator with the driving shaft, with the center lines of the pulleys directly opposite.

(5) Place the belt in position and run slowly.

If the shafts are parallel but the pulleys not directly opposite, the belt will run to one side of the larger pulley. If the pulleys are opposite but the shafts not parallel, it will run to one side of the smaller pulley.

(6) Secure the machine to its foundation.

As to the erection of coupled-type machines, proceed as directed under (1), (2) and (3) after which aline the generator shaft with the driving shaft and mount the coupling. Connect the coupling and run slowly; then secure the machine to its foundation.

The first operation in assembling an engine-type machine is the placing of the rotating part and engine shaft in its bearings. With machines of large size, the rotating member must previously be pressed upon the shaft in the station. The first operation then is the fitting of the hub to the shaft. The pressure required for this varies with the temperature, condition of surfaces, and quality of metal to such an extent as to make it practically impossible to estimate its value with any

degree of accuracy. In general, it is safe to assume that pressure of from 100 to 200 tons will be required for pressure allowances of from 0.004 to 0.006 in.

For pressing the rotating part onto the shaft, it is preferable to use a hydraulic press. When this can not be secured, make two yokes out of I beams. Set one of these in the rear of the rotating member and one at the end of the shaft and draw the rotating part into place by means of two bolts which pass through the yokes and spider close to the hub. Care should be taken to tighten up evenly on the bolts; otherwise, the hub will twist and bind on the shaft. Once started, this operation should be carried to completion as quickly as possible, as, if the rotating part is allowed to set several hours when only part way on the shaft, it may require from 25 to 50 per cent more pressure to start than was previously used.

After the rotating part has been pressed upon the shaft, it should be carefully lifted in a sling and lowered into its bearings.

(2) Set the bedplate in place and level up to proper position, i e., to such a height as will allow room for one-half of the liners allowed for adjustment under the frame when the air-gap is correct.

(3) Set the frame in position and adjust, shifting it in a direction parallel with the shaft until its center line (halfway between the ends of the laminated iron) is directly opposite the center of the rotating part (halfway between the end plates which hold the laminations of the core). Then drill the bedplate for the guide rail.

(4) Cement the bedplate to the foundation, using a mixture of one part of Portland cement and two parts of sand, or half cement and half sand; either will give good results. First mix the cement and sand dry and then add water until a very thin solution is obtained. Construct a dam around the bedplate and pour this solution under the bedplate, continuing the process until the cement stands about half an inch above the bottom of the bedplate. The entire operation of mixing and pouring the cement should be carried on without interruption and as rapidly as possible until completed, otherwise the cement first poured under the bedplate may partially set and prevent that poured later from flowing freely to all parts. When the cement has sufficiently hardened, remove the surplus from the outside and smooth up the joint under the bedplate. After the cement is hard tighten up the foundation bolts.

Adjustment of Air Gap

In setting up any machine in which the bearings are independent of the frame, great care must be exercised in adjustment of the air-gap between the armature core and pole faces, as any inequality in this gap will cause unnecessary friction and heating of the bearings and unequal heating of the armature iron. The unbalanced magnetic pull for 1/32 in. displacement is usually given on the outline drawings of large machines. Adjust the air-gap horizontally by means of the cross beams and jack screws upon the bedplate, and vertically by means of thin sheet-steel liners between the bed plate and the yoke. During this operation, gage the gap at different points on the front and back of the machine by inserting a small metal or wooden wedge in the air gap and noting the distance to which the wedge enters.

Questions and Problems for Review

1. Explain the relative copper requirements of two- and three-phase systems.
2. What means are employed to provide a 120-deg. displacement of electromotive force curves external to a three-phase generator?
3. What two general forms of three-phase armature connections are employed?
4. In a delta-connected machine, what is the value of the electromotive force to that in the individual armature winding? In a Y-connected machine?

The Torque Compensator

Its Function and Construction. By V. H. Todd

THERE ARE, in the various power houses throughout the country, thousands of alternating-current ammeters of all capacities and manufacture that do not read correctly because after they have been adjusted and calibrated, the first short circuit that occurs often

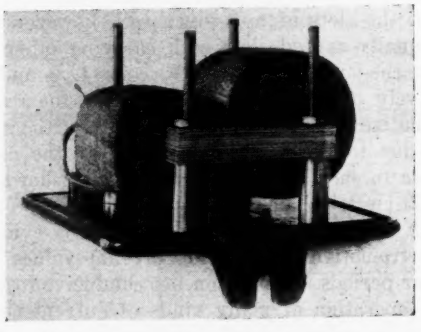


FIG. 1. ASSEMBLED VIEW OF TORQUE COMPENSATOR

develops such a torque in the meter that the pointer is bent, or moving element damaged or unbalanced, so the readings are not even approximately correct. Attempt to keep such instruments in calibration by the ordinary methods is practically impossible because of their inferior design. On early made instruments, it was not

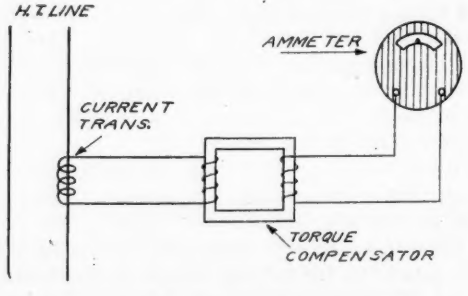


FIG. 2. SCHEMATIC DIAGRAM OF CONSTRUCTION OF THE TORQUE COMPENSATOR

realized what a terrific mechanical shock would be produced by even a mild short circuit; and when it is realized that the momentary current developed at the first instant of a violent short circuit may rise as high as 2000 per cent of the maximum meter rating and in addition, the torque of most a.c. ammeters increases as the square of the current, it is a wonder that the instruments are not more severely damaged than they are.

To produce such a rugged instrument, one manufacturing company requires a test of 200 amp. on a 5-amp. meter, and the meter must withstand this shock repeatedly.

To enable previous meters, not so ruggedly built, to withstand such service, a device called a "torque compensator" has been developed. This is shown in Fig. 1. Referring to the schematic diagram of parts in Fig. 2, it will be noted that this is merely a miniature transformer, with a primary on one leg of the magnetic circuit and a secondary on the other. The primary is

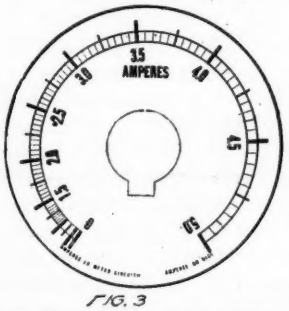


FIG. 3

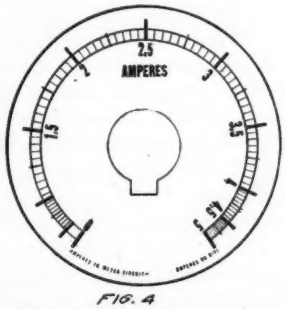


FIG. 4

FIG. 3. METER SCALE INDICATING THAT TORQUE CORRESPONDS TO SQUARE OF CURRENT

FIG. 4. SHOWING EFFECT OF TORQUE COMPENSATOR ON SCALE

connected to the secondary of the current transformer or in series with the line, and the secondary is connected to the meter. It will readily be seen that at low magnetizing values of the iron core, the secondary will receive its proper flux; but as the primary current increases, the core approaches saturation, and then no matter how much current is passed through the primary, there can be no more flux pass through the secondary and consequently the secondary can only deliver a maximum current which is only a little in excess of the full-load meter current.

The effect of the torque compensator is to crowd the upper scale divisions. For instance, in Fig. 3, is shown a scale with divisions which show that the torque responds to the square of the current, as 3.5 amp. is half scale and 5 amp. full scale. Figure 4 shows the effect of the torque compensator on the scale; the upper divisions are crowded, showing that the iron is becoming saturated and the torque is not increasing very rapidly. This brings 2.5 amp. at half scale and 5 amp. at full scale, a feature desirable in any alternating-current meter.

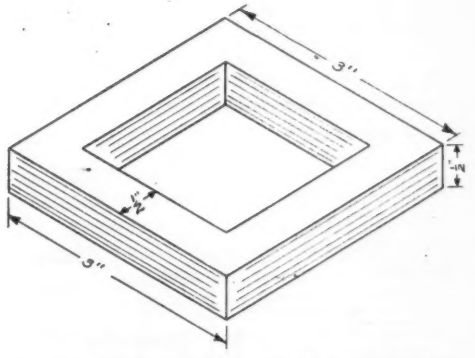


FIG. 5. DIMENSIONS OF IRON CIRCUIT OF TORQUE COMPENSATOR FOR AMMETER HAVING 5-AMP. SCALE

For the average alternating-current ammeter having a 5-amp. winding, a torque compensator may be made of laminated iron with dimensions as shown in Fig. 5. The primary may be wound with 80 turns for 60 cycles and the secondary with 40 turns, both wound with 0.0641 D. C. C. copper wire. For 25 cycles the turns should be changed to 160 primary and 80 secondary.

The chief objection to supplying new meters with torque compensators, is that the interlinking flux is largely affected by variations in the form factor of the various alternating-current waves; but if an ammeter is correctly installed with a torque compensator, and calibrated in position by comparison with a reliable root-mean-square ammeter standard, then the ammeter will read correctly, and there will be no danger of any overload or short circuit, no matter how severe.

Preventing vs. Correcting Poor Power Factor

DEVICES USEFUL TO THE ENGINEER FOR AIDING IN MAINTAINING THE LOAD AND POWER FACTOR OF INDUCTION MOTORS. BY H. GOODWIN, JR.

SUGGESTIONS for improvement in power factor may be divided generally into two classes: *corrective* and *preventive*. The corrective measure consists in the application of condensers, either synchronous or static. The preventive measures include the improvement of the power factor of motors by the use of synchronous motors or induction motors operating at full load.

The application of *corrective* measures is usually a problem large enough and so definite that it is placed in the hands of engineers with proper information and facilities for making recommendations. Further, the economy of correction can be definitely evaluated.

Application of *preventive* measures is apt to be a very intangible problem and to be in the hands of persons having little interest in it. New interest in it, however, is being added, in many cases, by the rapid introduction of demand charges proportional in some measure to the kilovolt-ampere demand instead of the kilowatt demand. So it behooves every power user to make studies of demand conditions in his plant either for present benefit or in anticipation of future benefit, or in an effort toward general national efficiency and economy in the use of our power supply. Many surveys have proved that, in general, industrial plants are largely "over motored."

It is therefore the purpose here briefly to suggest some devices which have proved useful to the practical plant engineer or electrician in meeting problems which really only he can solve satisfactorily. Doubtless many of these have read with interest articles on "over motoring" and the resultant poor power factor, but have

been at a loss as to how to apply them in their particular cases. They may have counted their total motor load and compared that with the demand and seen the large difference, and yet not know just what to do next.

The next step is to make tests, preferably periodic tests, and to keep a *record of the tests*. The accompanying illustrations show means for facilitating these two operations. They need not be followed absolutely, but may be modified to suit conditions in each plant or material already available.

It is essential that tests be made as far as possible without interruption to the service. Switches or fuses, across which instruments may be connected, are often in semi-accessible places where changing of instrument connections would be difficult. To meet both these conditions, it has been found very helpful to connect leads to the switch or fuses in the motor circuit, and carry these to a portable test board with switches and terminals for the ready connection of the instruments. Such a board is shown in Fig. 1. With the current and potential double-throw switches *a* and *b* open, connections are made to the circuit and instruments. Various screw connectors and clamps have been devised for connection to switches and wires and, for moderate sizes, have proved very satisfactory. The connections shown dotted are permanent and may be made on the back of the test board, or on the face with insulated wire. All back connections should be fully protected by another board. The fuses, switch blades or connections which have been bridged are then opened and everything is ready to take readings. Switches *a* and *b* are both thrown to position *A*.

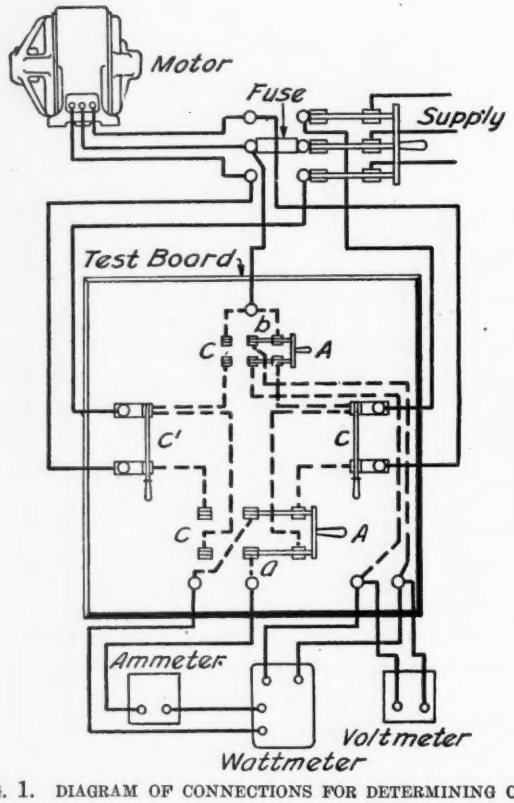


FIG. 1. DIAGRAM OF CONNECTIONS FOR DETERMINING CONDITIONS UNDER WHICH A MOTOR IS OPERATING WITHOUT SERVICE INTERRUPTION

It is noted that the voltage is approximately normal. The current short-circuiting switch *C* is opened, with readiness to close it quickly again should the ammeter scale be too low or should the wattmeter read reversed. The wattmeter connections should be checked carefully, because if the power-factor is below 0.5 the instrument will read reversed, and while it will be necessary to close *C* and interchange the current leads, the reading must be subtracted from the other phase reading obtained. To obtain readings on the other phase it is only necessary to close *C* and "throw over" *a* and *b* and open *C'*.

Then comes the duty of recording the readings obtained. The value of many important motor tests has been entirely lost because there was no systematic means of recording them. Some plants have made notable records for economy in use of motors and for high power-factor due almost entirely to a record system for motors and tests. Cards are used showing the location of every motor in service in the plant and those in stock or under repair. Other cards show motor locations and on these the test readings are recorded. This will be made clearer by referring to Figs. 2 and 3 which show cards suggested for this purpose. These cards may be ruled by hand, or printed, depending on the number required in each particular plant, and the information contained may be varied with local conditions.

The idea of the two cards is to separate conveniently the information which belongs particularly to the location of a motor from information about the motor itself, so that records of tests which belong essentially to the machine or group of machines driven will not be made inaccessible by transfer of the motor to another location. The "Motor Record Card" contains all the information pertaining to a particular motor and shows where it has been and is installed. On the back may be entered the record of any repairs made or other special information. The motor location card shows all the motors that have been installed at that location from time to time and the motor at present in service. The information about the motor is very brief; just sufficient to identify it so that the motor card may be found if further details are required. Stress is laid on the connected load and tests. The same form is continued on the back. In this connection care should be used to get tests under average, maximum and minimum conditions and so to note them. Tests should be made after a change in machines in a group to see if a change in the size of the motor either up or down is necessary.

Just filling out the cards for each motor and each location and making a short summary of them will probably bring out some interesting facts; but when the first round of tests is made, something is likely to be developed of considerable importance. The plant engineer is now ready to start improvements. If changes appear to be advisable, it will probably be well to check in each case, to be sure that conditions were not abnormal at the time of the first test. If some motor appears to be overloaded, an inspection of the tests of others may show one underloaded with which it may be interchanged with advantage to both. Some may be found enough below their capacity to warrant the purchase of new motors. In other cases, the over-capacity may not

be sufficient to warrant the purchase of a new motor immediately, but if extensions are planned, requiring motors of similar rating, new smaller motors may be purchased and the old motors relieved for the new service.

Tests should also be made under starting conditions. All such facts have a bearing on the motor required and will be invaluable in considering the purchase of new motors. And this leads directly to another thought. So far we have been considering improvement in power-factor only by running induction motors nearer normal

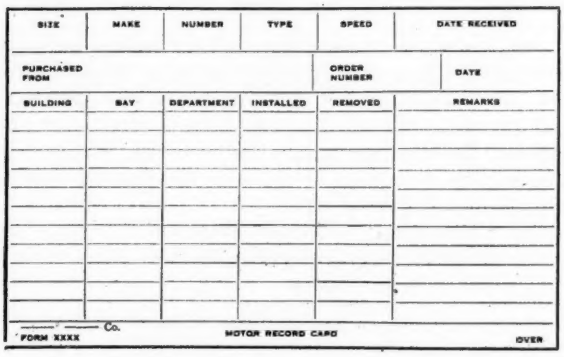


FIG. 2. TYPICAL MOTOR INFORMATION CARD

load. Tests may develop good cases for the application of synchronous motors. Synchronous motors have now been developed with ammortiseur windings in the pole faces giving starting torque equal to that of squirrel cage induction motors of the same rating. In the smaller sizes, the supply of exciting current still presents a little problem; but it is not beyond comprehension to conceive of a motor-generator set, centrally located, supplying excitation to a number of synchronous motors scat-

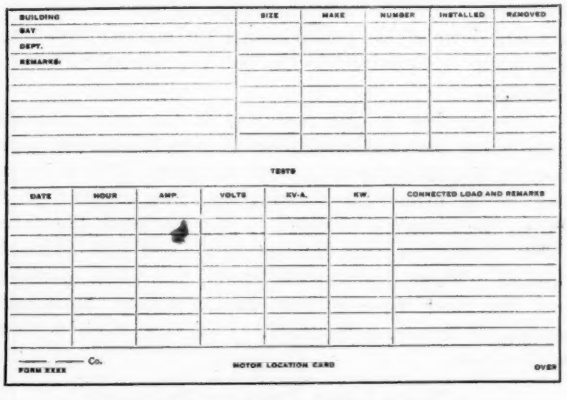


FIG. 3. TYPICAL LOCATION INFORMATION CARD

tered throughout the plant. The power-factor could readily be controlled on the whole group by varying the exciter voltage either automatically or by hand.

It is not proposed to review here the application of synchronous motors; but it should be noted that if smaller size synchronous motors can be installed throughout a plant, they improve the power-factor on the distributing mains and so increase their capacity. If such synchronous motors can be installed with capacity for leading current, thus providing also for the *correction* of power-factor, so much the better. Care should be used in ordering such motors to specify what leading current or power-factor they shall carry.

Let us not consider any details in connection with poor power-factor too small for attention, but, by careful tests and records of them, determine upon means for *prevention* of troubles before they accumulate to an amount requiring correction.—General Electric Review.

Capacity Effect of High-Tension Feeders

By J. T. Kane

CAPACITY reactance of unloaded transmission lines and cables may be utilized for power-factor correction on the alternators feeding them. One electrical system has two transmission lines of high capacity reactance which are frequently run without load and utilized as static condensers for the purpose of improving the power factor of the system.

For various reasons, the charging current of the transmission line is of interest to its operators. The current that the line takes at no load may be appreciable, and must be reckoned with in any tests made on the line or on apparatus fed over it. In most companies, all new or repaired high-voltage equipment is given a breakdown insulation test by applying specified testing potentials between the conductors themselves and between all conductors and ground. As this test is made from the generating station, unless the charging current under such conditions of the transmission line over which the test is being made is known, the current in the testing circuit will not show whether or not the apparatus being tested is defective.

The condenser effect of transmission lines and cables is most noticeable on relatively small generators. In one 4000-kw. standby steam plant feeding into a 13,000-v. system through a step-up transformer and 3 mi. of lead-sheath cable, the generator voltage was increased 5 per cent by the leading reactance of the transformer and cable. In another station having 6000-v. alternators and feeding out over a total of 20 mi. of three-conductor, lead-covered cables, the charging current of those cables was 30 amp. and their reactance increased the generator voltage 7 per cent.

If the proportion of transmission line capacity to generator capacity were great enough, the leading reactance of the transmission lines could be utilized to excite the generator; if not entirely, at least to effect a considerable reduction in the excitation wattage on the generator field. A synchronous motor somewhere on the system would then be required to stabilize the generator and hold it in synchronism.

PLANS for reconstruction of the operating organization of the Pennsylvania Railroad system on termination of Government control on March 1, have been adopted by the Board of Directors. Among the changes are greater unification of system for operating purposes, establishment of new organization affecting all departments and creation of regional plan of operation and management.

Power Plant Troubles

Methods Used in Overcoming Them. By H. A. Jahnke

AT TIMES a power plant engineer may get into trouble with some apparatus in the plant, and often it takes a long time to get out of the difficulty. For this reason I thought it would be of interest to relate how I cured some of my troubles.

Return Trap Troubles

I use a tilting trap for returning the water of condensation to a direct return trap, used for boiler feeding. I used to have much trouble with this trap not working properly, due to the fact that the receiving tank into which all condensate runs could not be set high enough for the condensate from the receiver to run freely into the trap tank, with the result that it took too long for trap tank to fill, so that the trap would operate. The receiver could not be set higher on account of the return pipe from the heating system which was laid below a concrete floor as shown in Fig. 1. The trap could not be set lower, so I was up against it for a while, until I hit upon the idea of placing the tank A next to the trap pit on the floor, then piping it up as shown. In this way, should the trap tank not fill quickly enough to make the trap operate so as to empty the receiver, the water of condensation will back up into the tank A, through the pipes B and C thereby placing more pressure on the trap tank and filling it quicker. In this way there is no danger of the return pipe filling with condensate to the coils as before.

Somebody may be under the impression that the return pipe from the coils could have been raised so as to get more pressure into the receiver. This, however, could not be done in this particular case on account of the building, and the location of the machines.

Bypass to Trap

In a one boiler plant where it was necessary to leave steam on the heating system at night, the fire was banked under the boiler during cold weather, as there was no watchman or night fireman.

The boiler was fed with water by a direct-return trap of the tilting type during the day, and boiler filled to the top. The next morning the water would be quite low in the boiler and little steam left, when it was necessary to run cold water into the boiler. When sufficient steam pressure was raised the trap was started to fill the boiler.

To overcome this low water trouble in the morning, the main valve in the water supply pipe to the trap was bypassed, as shown in Fig. 2, with a ⅜-in. pipe and valve. At night, after the boiler is filled, the valve in the 2-in. line is closed and the ⅜-in. valve opened a few turns. How far the ⅜-in. valve was to be opened was found by trying it one day when the boiler was only furnishing steam for the heating system.

With this system the steam is left on the direct return trap at night and the ⅜-in. bypass valve opened. The water in the boiler does not drop much during the night below what it was the night before.

I suppose somebody will say, "Why was the water not regulated to the trap by the valve in the 2-in. line?" This 2-in. valve is of the gate type and it is quite hard to adjust a valve of this kind, as only a little water will run through it. For this reason the ⅜-in. globe valve was used.

To Prevent Scale and Sediment from Getting into Pipe

Where water is kept in a tank for storage purposes more or less scale and sediment settles at the bottom of the tank. Then, should water be drawn from the tank and the pipe is located at the bottom, this scale and sediment will be drawn into the pipe, thereby perhaps clogging up some pipe or valve in the line, or causing trouble in some other way.

To prevent this, we have extended the pipe into the tank about 18 in., as shown in Fig. 3, by using 2 flanges bolted to the bottom.

"Draining a Soap Sump"

In a large laundry where all soap suds from the wash machines is run into a sump to be filtered and used over again, at the end of the week it is necessary to pump this sump clear to the bottom for drawing the suds into the wash machines. For emptying the sump, a centrifugal pump is used. A short time ago, the pump refused to pump the water much lower than shown by the dotted line in Fig. 4, which also shows an outline of the sump and piping, etc. After examining pipe and pump a number of times, nothing was found wrong, when, being in the sump, I noticed that one of the packing nuts on the gate valve was quite loose. I thought that this, perhaps, was the cause of our trouble, so screwed down all the packing nuts and started the pump. The sump was drained to the bottom without any more trouble.

The trouble in this case was in the valve packing nuts being loose and admitting air into the suction pipe, thereby breaking the vacuum of the pump. The arrangement of the piping for draining the sump is shown at A. When the suds are pumped to the machines the three valves with the long handles are closed and valve E opened. When draining the sump, this valve is closed and the other three opened, one at a time, until each section of the sump is empty. It is then washed clean with a hose.

A Troublesome Pressure Regulator

A new 2-in. steam pressure regulator of the type shown in Fig. 5 was installed in a steam line to reduce the steam pressure from 120 to 5 lb. for the heating system. After the steam was turned into the pipe it was found that the regulator would not work automatically, as it should, but had to be assisted by hand in moving the piston up or down. At first it was thought there was too much oil in the dashpot or that some foreign matter had gotten into the cylinder. This, however, was not so.

We had about decided to return the regulator to the

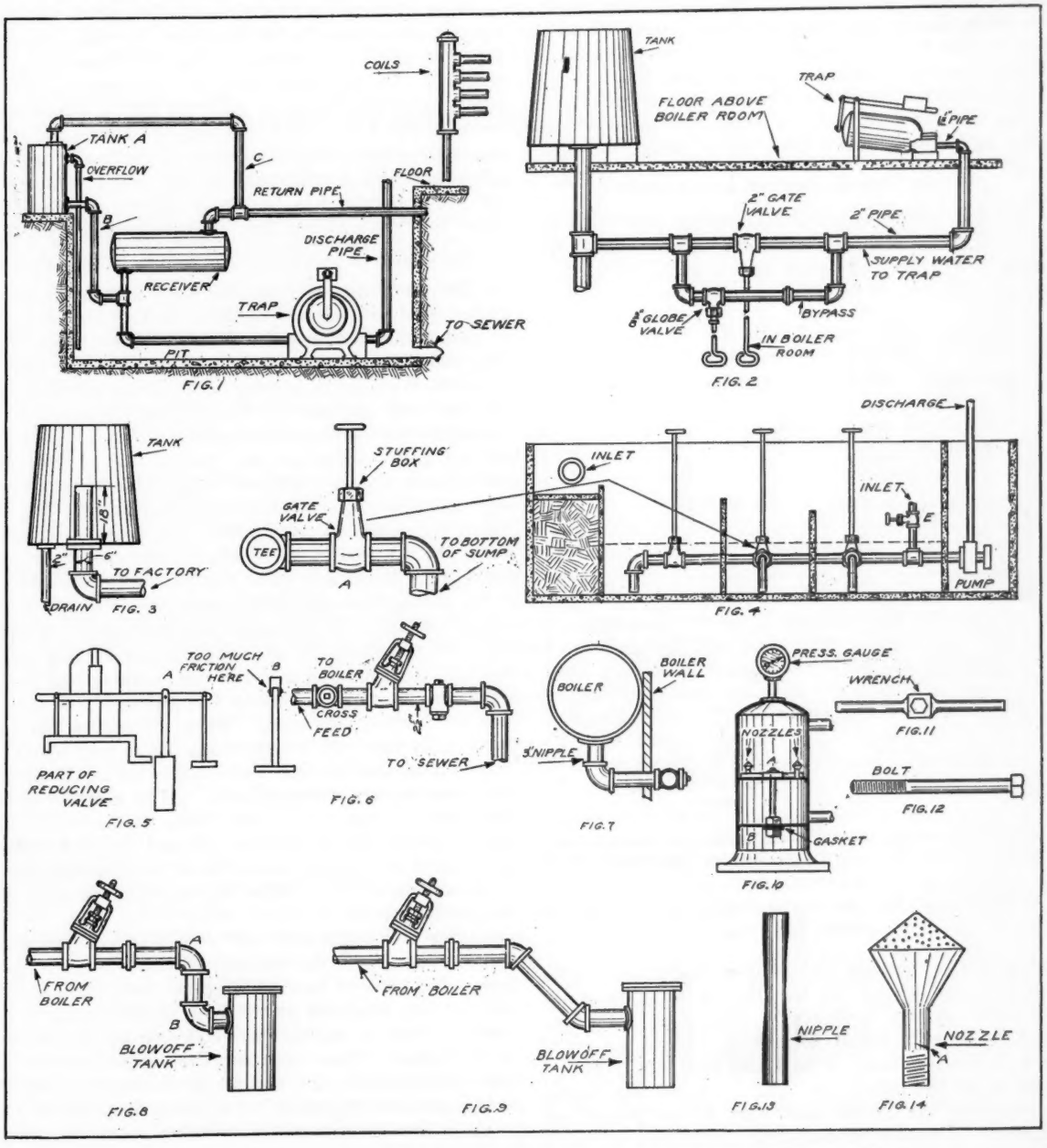
dealer, when, taking it apart, I discovered that there was too much friction at the joints A and B, where the parts are connected to the dashpot rods. After removing this friction from the joint by filing, the regulator worked as it should.

Blowoff Valve Trouble

The blowoff pipe on a return tubular boiler was equipped with two valves, one a "Y" valve, the other an asbestos packed cock, both 2½-in., as shown in Fig. 6. One day it was necessary to renew the asbestos packed cock, as it leaked badly around the plug when it was opened or closed. No tightening up on the nuts stopped the leak. In placing the new cock, the engineer thought it wise not to close it, as the "Y" valve did not leak and his intention was only to close the cock whenever the "Y" valve leaked, so he left it open for several months.

Some time after this, when blowing down the boiler, it was found that the "Y" valve leaked. In trying to close the cock he was unable to do so; it was not possible to turn the plug with a 36-in. pipe wrench. Heating the cock did not help any. Some scale forming matter must have gotten between the plug and cock, preventing the plug from turning, so the cock was not closed, but a new one was placed at the first opportunity.

I believe it is poor practice to leave a cock of this kind open for long with muddy and scaly water passing through it. It should be opened and closed frequently,



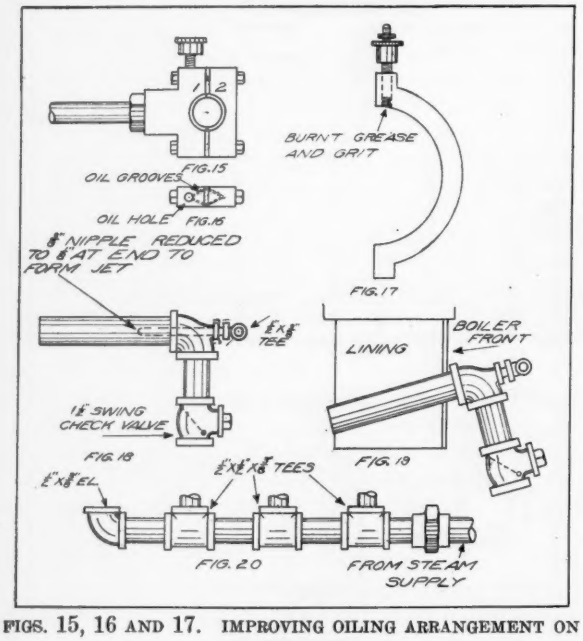
FIGS. 1 TO 14. SHOWING THE CAUSES OF THE TROUBLES AND THE REMEDIES APPLIED

so no scale or other foreign matter will settle on the working surface to prevent the opening or closing of the cock.

In another instance, the blowoff pipe on a return tubular boiler which is set 48 in. from the grates was arranged as shown in Figs. 7 and 8, running through one of the side walls, then along the wall to the blowoff tank. Whenever some of the dirty water was blown out of the boiler under pressure, the pipe would lift up, from blowoff valve to the tank, between elbows A and B, showing that there was much strain at these joints. The arrangement was changed to that shown in Fig. 9, where 45-deg. elbows were used in place of 90-deg. After this change the pipe did not lift when blowing down the boiler, as the water had a freer way of getting out.

Water Filter Trouble and Remedy

We had much trouble in keeping the joint tight between the nut B and the bottom head of our water filter, shown in Fig. 10. The joint here is made with a lead



FIGS. 15, 16 AND 17. IMPROVING OILING ARRANGEMENT ON ECCENTRIC ROD

FIGS. 18, 19 AND 20. IMPROVED STEAM JET BLOWER FOR BOILER FURNACE

gasket next to the head and an iron washer next to the gasket, drawn up by the nut B. In order to renew this gasket it was necessary to remove all the gravel from the filter to get at the nut A. Above the gravel plate it was necessary to hold this nut with a wrench so as to get the bottom nut off. To avoid this trouble of removing the gravel each time a new gasket was necessary. I made a wrench of the type shown in Fig. 11 to fit over the nut above the gravel plate. The handles on this wrench are long enough to reach two of the water nozzles, as shown in Fig. 10. To keep the wrench and nut from turning when turning the bottom nut, the end of the bolt at nut A was riveted over so the nut would not come off when taking off the bottom nut. In this way it was not necessary to remove the gravel when necessary to remove the lead gasket at the bottom head. This saved about five hours' labor, time and other expense.

While examining other parts of the filter at this time, I found that the heads and nuts on the bonnets of the valves of the filter were in very bad condition and nearly eaten away by rust, as shown in Fig. 12. It is a wonder that they did not let go, as there was 60 lb. pressure in the filter. These bolts were renewed at once.

Some of the piping which was connected to the filter was also eaten away to the thickness of a piece of newspaper by the rust, as shown in Fig. 13. These were also renewed. On this same filter it was noticed, at one time, that much fine sand from the gravel would come out with the water while washing the filter (the washing of the filter is done by reversing the flow of water). After looking for the trouble it was found that one of the water nozzles was broken, as shown in Fig. 14A. After this was repaired there was no further trouble.

Remedies for Defective Eccentric Lubrication

The eccentric rod bearing on a high-speed steam engine used to wear so quickly as to make it necessary to adjust the bearing quite often to prevent knocking. The bearing is lubricated by means of a grease cup as shown in Fig. 15. In looking for the cause for the wear, I found that the half of the bearing, 2, received no grease, due to the fact when turning down on the grease cup all grease would go into bearing 1. To overcome this trouble, I cut oil grooves from center of both bearings up to the edge, as shown by dotted lines in Fig. 16. When the cup is screwed down the grease will work along the oil grooves in bearing 1 into the grooves in bearing 2. After this there was no further trouble.

In another instance on this same engine the eccentric started to heat. I was under the impression, at first, that the automatic grease cup was not feeding as it should. In examining this, however, nothing was found wrong, so the cup was refilled and replaced, first seeing that the oil hole was clear. When the engine had run for a short time, the eccentric started to heat again; I also noticed that the cup was not feeding as the grease cup stem was not working down. After shutting down, the eccentric was taken apart, when it was found that the bottom of the oil hole was clogged up with burned grease and grit, which became hard, and through which no grease could work. After this was removed there was no further trouble.

After this experience the eccentric was examined quite frequently to see that the oil hole was clear, as I have often noticed that some grease containing matter which turns hard and gritty when it gets warm or hot and will bake to any surface and clog up the oil hole at the bottom. Then when running a wire into the hole and striking this hard matter one is apt to think the hole is clear to the eccentric. To make sure that the hole is clear, the eccentric should be taken apart frequently.

Steam Jets for Smoke Consuming

In many steam plants, steam jets are used under the boiler for preventing smoke. For admitting air into the furnace above the fire along with the steam, either there are holes in the fire doors or air is admitted in some other way. In most cases these openings are open continuously. This is wasteful of fuel. To overcome this trouble I have arranged my steam jets as

shown in Fig. 18, where a 1½-in. pipe is run through the boiler front and setting, as shown in Fig. 19. The 1½-in. pipe at the boiler front is equipped with a 1½ by ⅜ by 1½ in. tee. Into the 1½-in. opening a short nipple is screwed, then a 1½ in. swing check valve, which admits air when the steam jets are in operation and closes when the steam is shut off. In this way no cold air is admitted into the furnace continuously. The steam jets are made of ⅜-in. nipple, with one end reduced to ⅛ in., screwed into ½ by ½ by ⅜-in. tees. The ⅜-in. holes in the 1½ by ⅜ by 1½-in. tees are enlarged so the ⅜-in. nipples slip into them. Should it be necessary to take any of the steam jets out to replace them, all that is necessary is to disconnect a union, as shown in Fig. 20. The number of steam jets to be placed in a furnace depends on the size of the grates. My grates are 5 ft. wide by 5 ft. 6 in. long and have four jets in use which give good results. Using the swing check valve for admitting air and closing it off is an idea I learned from another engineer.

Power Transmitted by Belting

DERIVATION OF COMMON FORMULAS AND HOW TO USE THEM. BY H. M. BRAYTON

THE MACHINE and factory designer, as well as the plant engineer, continually are called upon to determine the proper width and ply of belt to deliver a given power. Usually, the power, speed of belt and size of pulley are known and the belt width is desired. When a machine tool of the power type is first designed, the engineer is called upon to determine the size and width of pulley to specify. Usually, in this case, he knows the speed of the drive shaft and the power required to drive the machine tool under its maximum load.

Even the millwright is often called upon to determine belt width, and it will be the aim of the writer to simplify the formulas so that the average shop man, with a little time and study, can use them as well as the trained engineer. If the shop man will only take the trouble to read this discussion carefully, he will find himself more independent of those over him, will know his work better, and will take more interest in the technical side.

Many of the machines now installed in our modern shops have the individual motor drive. If the time ever arrives when this practice becomes universal, then the belt drive as we know it today will be a matter of history. But how many men, even of the far-seeing type, think that the overhead drive shaft and the belt drive are soon to be superseded? The answer to this, in the writer's opinion, is, "very few." There are certain classes of work where the belt drive will probably always be preferable. The average shop cannot afford to make an entire change of equipment and scrap perfectly good machines merely because some engineers have shown that the electric drive is more efficient. The gain realized by the added efficiency of operation would not pay a respectable return on the capital involved.

The reader can appreciate, therefore, that even if the belt drive is doomed to be superseded ultimately by the more efficient electric drive for each unit, the day is far distant. It will probably not come in our day and generation. If this be true, then it is our duty to keep posted on the belt drive and how to determine the various factors entering into the design. Such is the purpose of this article.

When a belt is delivering power from one shaft known as the driver to another shaft known as the driven, one side of the belt, usually the lower side, is tight and the other loose. The latter is, of course, moving toward the driven pulley. Some men think that only the tight side is under tension. We usually designate the tension in the tigh side by T_1 and the tension in the loose side by T_2. The driving force on the pulley is then the difference between these two tensions, or $T_1 - T_2 = P$.

This tension in the belt must not exceed the working strength of the material from which the belt is made. This working stress is always considerably below the actual tensile strength of the material as determined by tension test. The reason for this lies in the fact that the belt is called upon to withstand a wide fluctuation in stress as well as continuous bending over the pulley. This bending loosens the fibers and produces an effect on the material much the same as the well-known fatigue so common in all metals. The larger this working stress is made, the shorter the life of the belt. Engineers usually try to fix the value so that the ratio between the power transmitted and the cost of the belt per unit time will be as large as possible. Too low a value would not be economical, as the cost of the belt per horsepower-hour would be higher than a higher value for the tension, coupled with a shorter life. Engineers are practically agreed that a value of 35 lb. per inch of width for double belts is high enough for the working stress.

Extensive tests have determined that belt speed should not exceed 5000 feet per minute. A good way to remember this value is to think of it as a mile a minute. Slower speed than this is, of course, desirable if possible, although this value will give the best efficiency where possible. The speed of the belt may be determined by a special instrument held against the running surface, or it may be determined from the size and speed of one of the pulleys. The latter method is more often used. If the speed of the pulley is not known it can be measured accurately enough by an ordinary watch and counter.

With the above information determined, we may obtain the linear speed of the belt by the following formula:

$$V = \frac{3.1416\,D\,N}{12} = 0.26\,D\,N \qquad \text{(Eq. 1)}$$

in which

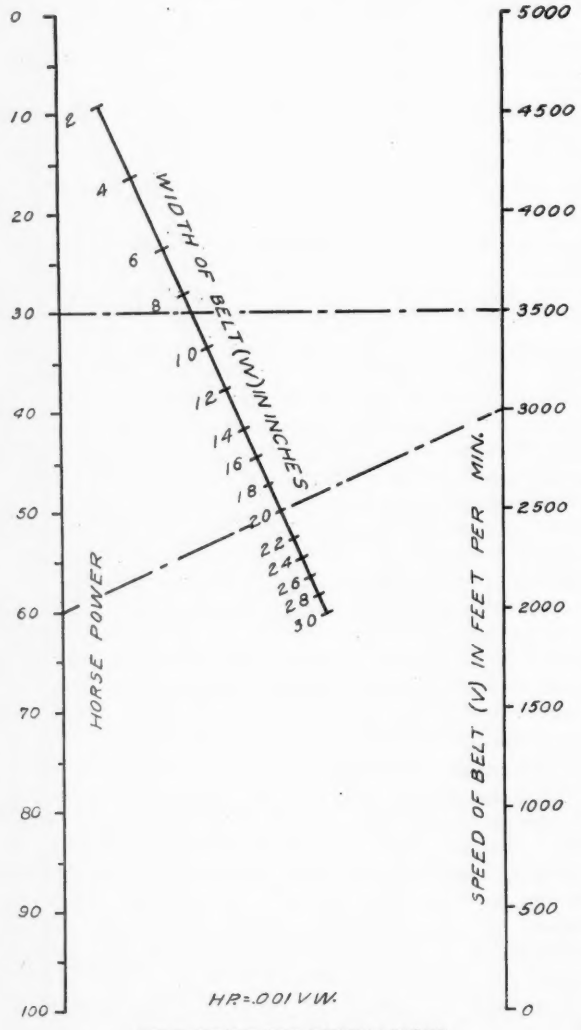
V = velocity of belt in feet per minute.
D = diameter of pulley in inches.
N = speed of pulley in revolutions per minute.

In case we are planning a new machine, we may as-

sign any value, within reason, which we may desire to the speed. The above formula is needed only when the line shaft is all installed together with the driver pulley. The shop man can also arrange the pulley size to suit his convenience and to suit what he happens to have on hand.

With the velocity and belt tension known, we may proceed to write the horsepower formula. This is fundamental.

$$hp. = \frac{P\,V\,W}{33{,}000} = 0.000{,}030{,}3\ P\,V\,W \quad \text{(Eq. 2)}$$



BELT CHART FOR DOUBLE BELTS

As we do not always care to solve for the belt speed, we may substitute equation 1 into equation 2 and obtain $hp. = 0.000{,}030{,}3\ P\ W\ 0.26\ D\ N = 0.000{,}007{,}88\ P\ W\ D\ N$ (Eq. 3)

Equation 3 will give the power which can be safely transmitted by a belt when the value of the working stress has been assigned and the value of the width, diameter of pulley and speed of pulley is known. This formula is very useful, and the average shop man should have it handy for ready reference. As it is necessary to assume the value of P in this formula, we are not justified in extreme accuracy in the value of our constant. The formula may, then, be written as follows without appreciable loss in accuracy.

$$hp. = \frac{P\,W\,D\,N}{12{,}000} \quad \text{(Eq. 4)}$$

Equation 4 will be found easier to handle. We may also go one step further and substitute the value of P. Different engineers may have different values for this working stress, but if we assume 35 lb., we obtain

$$hp. = \frac{35\,W\,D\,N}{12{,}000} = \frac{W\,D\,N}{350} \quad \text{(Eq. 5)}$$

which is still easier to handle and will give very good results.

One might think that the faster a belt runs, the better because it is a fact that the greater the speed, the less the required tension in the belt with the same power transmitted. This is nicely shown in equation 5. If the speed of the pulley N is increased, the power is increased in direct proportion, other factors remaining the same. We have entirely neglected centrifugal force in the foregoing discussion, and this force is very much in evidence, especially at the higher speeds. It has been found from experiments that it is not advisable to run a belt above 5000 ft. per minute, because at speeds above this value centrifugal force throws the belt out away from the pulley, thus causing excessive slippage.

Referring now to equation 2. If we substitute into this formula the value of $P = 35$ lb., we obtain,

$$hp. = 0.000{,}030{,}3 \times 35\ V\ W = 0.001{,}06\ V\ W$$

Again, our assumed value of P does not warrant great accuracy, and we can write this equation still more simple as follows:

$$hp. = 0.001\ V\ W \quad \text{(Eq. 6)}$$

which is very simple and a formula which any shop man can use. All he needs to know is the speed of his belt, V, in feet per minute and the width, W, in inches to obtain the horsepower which it will safely transmit.

The writer considers equation 6 of so much importance to the plant engineer, designer and shop man that he has deemed it worth while to build it up into a simple chart from which any one of the three variables may be quickly read off when the other two are known. Such a chart is shown herewith. The limits of the scales have been chosen to take in the usual range of values. To use the chart, it is necessary merely to connect the two known variables found on their respective scales with a straightedge or line and the third variable, whose value we desire, will be cut out on the third scale. The dot-dash line illustrates the use of the chart. If we have a 20-in. belt running 3000 ft. per minute, a line connecting these two values on the right-hand vertical scale and the diagonal scale when extended to meet the left-hand vertical scale cuts out a value of 60. This means that a belt running at the stated speed will deliver with safety 60 hp.

Again, suppose we desire to transmit 30 hp. at a speed of 3500 ft. per minute, how wide would the belt have to be? The upper dot-dash line illustrates this problem. Merely connect the 30 hp. with the 3500 ft. per minute found on the left and right-hand scales, respectively, and note that the line cuts out a width of belt somewhat over 8 in. Use a 9-in. belt. The reader

should cut this chart out and pin it up on the wall or some other convenient place where it will be ready for instant reference. It will save much tedious calculation and will eliminate errors. The chart is correct and one is not nearly as likely to make an error reading a chart as he is to make an error in his figures.

Thus far, the whole discussion has been based upon double belts. For single belts the formulas hold good just the same, except that a different value for the working stress P must be used. The Manhattan Rubber Co. has worked out constants to be used with its belts for the different plies. The chart and formulas given above apply to the 4-ply. If other ply is used, the following table will give the factor to use. This is quoted only as an illustration of what this company recommends for use with its own make of belt:

Ply	4	5	6	7	8	10
Factor	1	1.3	1.7	2	2.3	3

This means that if you are using a belt which has more than 4 ply, you must multiply the values which you obtain for the power transmitted from the above formulas by the coefficient which goes with the ply used. If we have 7 ply the power transmitted may be just twice that obtainable from 4 ply.

When selecting either the size or make of belt one factor cannot be impressed too strongly upon the minds of those who have this important duty to perform. This fact is that the life of the belt must be carefully considered. Tie ups in production should be reduced to a minimum by installing belts which will give the maximum of service. It must be remembered that the greatest loss is not from the cost of the new belt, or the cost of repairs to the old one, but from the work lost due to the machine being idle. Managers should exercise care to see that responsible persons are placed in charge of this work.

Properly Balancing, Fuel Lubricant and Motor*

By William F. Parish

DILUTION of motor lubricating oil is caused by the gasoline mixture escaping past the piston rings, with a possible secondary cause—drainage of the diluted oil from the cylinder wells. In the earlier years of highly volatile gasoline the gas escaping past the piston rings did not enter extensively into the body of the lubricating oil, and while mechanical losses of fuel took place in all four-cycle engines, this loss did not reflect itself in a problem of dilution. In the past few years, however, due to the heavy end components of the fuel, a larger amount after passing the rings, upon condensation, remained in the lubricating oil, thus creating a condition of dilution.

Not until the period of high end point gasoline did the matter of fuel loss become apparent, then only in proportion to the amount held in solution in the lubricating oil. This condition, which has become especially accentuated in the past 3 or 4 yr., has resulted in undue wear upon the engine parts as well as affecting the use of fuel, lubricant, and power.

During the war, it was necessary, before writing specifications for lubricating oils and fuels for aeronautics and other internal combustion engines, to make a complete study of this subject in order that the fuel and lubricants could be so balanced that their combination in the engine would give the necessary lubricating results. These main tests resulted in the specification for Liberty Aero Oil, and had much to do with specifications for Aviation Gasolines, including Domestic, Export and Fighting grades. A Hall-Scott, Type A-7-A, four-cylinder, 100-hp., aeronautic engine was used for the special fuel tests of the series. This engine was operated under ideal test conditions, working with the same lubricant but with different fuels. Two of these fuels were especially made for the test and were distilled from the same crude. The first fuel tested was made after the German specifications for aviation gasoline, and had a gravity of 75.2 deg. Be., with initial boiling point of 110 deg. F. and a final boiling point of 230 deg. F. The second fuel tested was made after the French specifications and had a gravity of 63.6 deg. Be., and an initial boiling point of 140 deg. F., with a final boiling point of 292 deg. F. The third fuel was regular Navy specification motor boat fuel and had a gravity of 61.3 deg. Be., with an initial boiling point of 135 deg. F., and a final boiling point of 385 deg. F. To the last fuel a so-called gasoline energizer was added which produced a fuel which, while it had an initial boiling point of 135 deg. F., had an end point of 422 deg. F., which in its last distillation range would be equivalent to the present day commercial gasoline.

The method of conducting the test was to run the engine continuously for 5 hr. under test conditions, every observation in connection with the operation being recorded. At the end of every hour samples of lubricating oil were drained from the lubricating system of the engine and the same amount of new oil replaced. These samples were then examined by chemists.

The effect of the four different classes of fuel upon the same lubricant is clearly registered in Fig. 1. The lightest or most volatile fuel shown in test 3 caused a lowering of the viscosity of the lubricating oil during the first hour of 30 sec. (viscosity Saybolt Universal Viscosimeter). The oil, however, recovered its body, and at the end of the fifth hour was 44 sec. above its original viscosity or body.

In test 2, with a slightly heavier fuel, there was a reduction in the body of the oil of 46 sec. during the first hour. The oil, however, after the first hour recovered and had a viscosity of 28 sec. above its original body at the end of the fifth hour.

Test 1 with a semi-commercial fuel, showed a drop in the body of the oil in 2 hr. of 150 sec., with a slight recovery during the balance of the test. There was a total reduction of 16 sec. at the end of 5 hr. from the body of the original oil.

In test 4 with the high end point gasoline, there was a drop in 2 hr. of 142 sec. in the body of the lubricant, only a slight recovery and a total drop at the end of 5 hr. of 108 sec. from the original body of the oil.

* Abstract of paper presented at Chicago Branch Meeting of A. S. M. E., Jan. 23, 1920.

The sample taken at the end of the 5 hr. period of each one of these tests was tested in a distillation flask and the amount of heavy end of the gasoline recovered varied from 0.5 to 1.2 per cent, as indicated in Fig. 2. All of the physical characteristics of the oil, such as gravity, flash, fire, viscosity, pour test, acidity, carbon content, showed a considerable change as indicated in Fig. 4.

The results of the above tests show quite clearly that dilution exists with even the most volatile fuel,

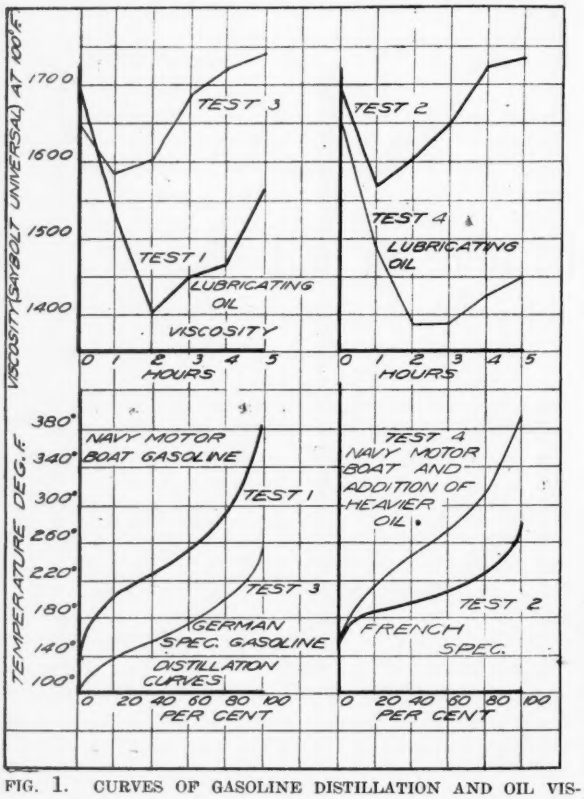


FIG. 1. CURVES OF GASOLINE DISTILLATION AND OIL VISCOSITY SHOWING CHANGE IN LUBRICATING OIL WHILE WORKING IN ENGINE

but only during certain periods of the operation of the engine and under certain fixed conditions. With the lightest volatile fuel, which would also be the case with the engine operating on producer, natural or furnace gas, the tendency of the lubricating oil would be to build up in body, the same as in any other class of lubrication work where the lubricant does not come in contact with lighter hydrocarbons or lighter volatile products that can be combined with it. The above tests also indicated quite clearly that the heavier the end point of the fuel, the greater is the effect of dilution, also more permanent is its character.

The following data were secured from the examination of lubrication conditions of a considerable number of cars and trucks using commercial gasoline and lubricants as purchased in the Chicago market. The cars, in some cases, were new as received from the manufacturer, and in other cases old, and old repaired.

The method of conducting the test was first to clean the motor thoroughly, then fill the crank case with the oil to be tested. The oils so used covered a range of commercial medium and heavy grades as indicated by government specifications. The cars were then allowed to operate in their regular business for periods of ten days during which time no particular care was given them other than ordinarily given commercial vehicles, but at the end of each two-day period an 8-oz. sample would be drawn from each crank case and 8 oz. of the same oil used on that particular motor would be put in with whatever additional oil was necessary. The samples were examined for dilution by measuring all the product that could be distilled from the sample of oil under 500 deg. F. The viscosity of the sample before removal of the diluent was taken on a Saybolt Universal Viscosimeter at 100 deg. F. The method of making the ash test was first to test the oil in the Conradson carbon apparatus. After the carbon was determined a gas flame was used for burning the carbon out of the dish. The ash that remained was then weighed and percentage taken of the whole sample. This ash was made up of iron, iron oxide and silica.

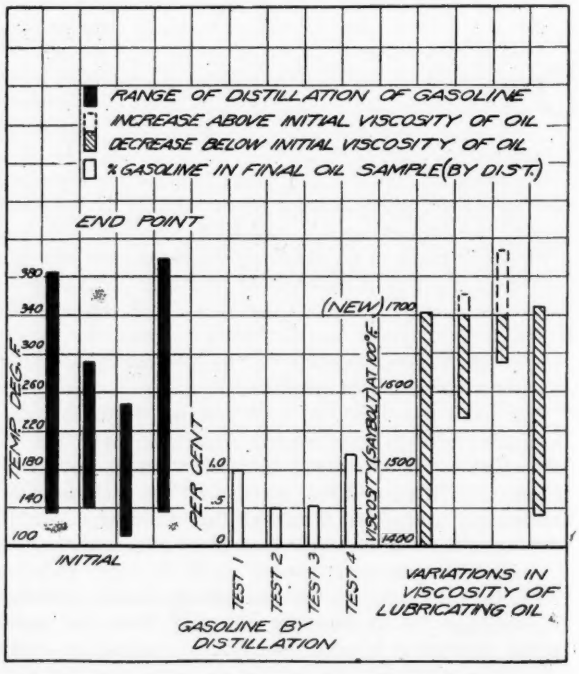


FIG. 2. AMOUNT OF HEAVY END OF RECOVERED GASOLINE

Figure 5: 3½-ton Diamond "T" truck. This was a new car never run previous to this test. Viscosity at the end of ten days was reduced from 345 to 100 sec. Dilution the tenth day amounted to 19 per cent; ash, 1.62 per cent.

Figure 6: Five-ton Pierce-Arrow truck that had run 5205 miles. On July 4, 1919, this motor was completely overhauled, new piston rings being fitted. Viscosity dropped from 358 to 90 sec. during the first six days, then recovered to 184 sec. at the end of ten days. Dilution in the case of this truck seemed to be dependent upon weather conditions; at the end of the 6-day period there was 20.6 per cent of dilution which was reduced to 8 per cent at the end of the 10-day period.

Figure 7: 3½-ton Packard truck, had run 12,551

miles. Overhauled May 5, 1919; new rings fitted. The viscosity held practically constant for the first two days when the truck was not operating in the open. After the second day there was a drop in viscosity to 43 sec. Dilution at the end of the tenth day was 26.5 per cent.

Cause of Dilution

With present day fuel and automotive engines, all lubricants change considerably in body within a short operating period, this new body being the result of dilution and the dilution coming from the heavy end of the fuel.

Amount of dilution is, to a great extent, influenced by the temperature of the surrounding air, the reason being that the colder the engine and oil in the engine, the greater will be the amount of fuel it will absorb and hold. Conversely, the hotter the air or lubricating oil in the engine, the less will be the amount of fuel held in dilution, as all the fuel can be distilled off at high temperature.

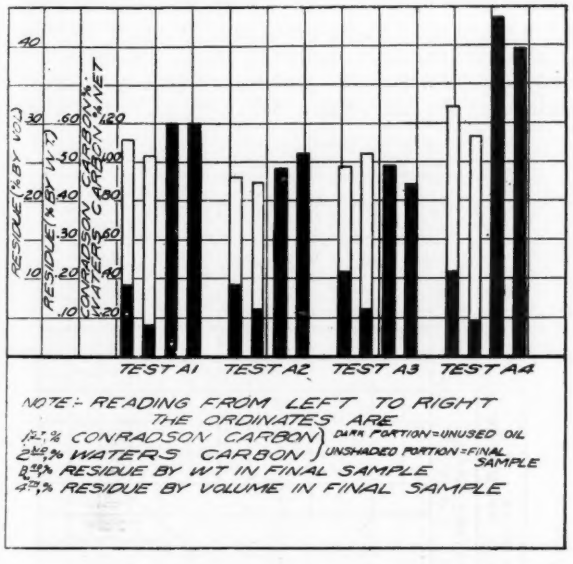


FIG. 3. CHART OF CARBON CONDITIONS

In order to see if any of the dilution of a motor-oil could be caused by decomposition or cracking of the oil by being thrown against hot surfaces, tests were made with a commercial car operated by pure benzol. Percentages of 4 to 8 per cent of benzol were distilled from the motor oil after 100-mile runs. The oil after the benzol had been removed possessed all of its original characteristics. Benzol can be determined as such by the chemist wherever found. These Benzol tests determined satisfactorily that dilution was being caused by the fuel, though the burned odor of the oil did indicate some degree of decomposition.

Dilution is caused mainly by leakages past the piston rings during the compression stroke. There is a secondary leakage caused during the suction stroke, where there is a partial separation of heavy ends of the fuel from the gas entering the cylinder and absorption by the film of oil on the cylinder walls, causing some drainage on the lower exposed surfaces during the compression stroke. It is doubtful if any drainage or leakage takes place during the exhaust stroke or during the power stroke. If we assume that the losses take place during the admission and compression strokes, we are dealing with one-half of the operating period of the engine and that will give all the opportunity necessary for the effects that have been noticed to take place.

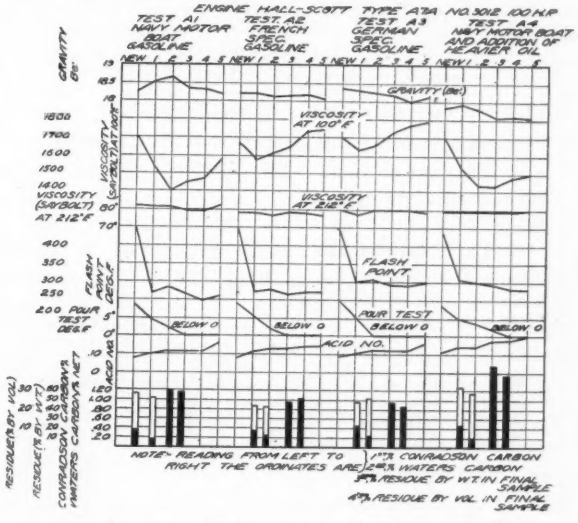

ENGINE HALL-SCOTT TYPE A7A NO.3012 100 H.P.
TEST A1 NAVY MOTOR BOAT GASOLINE
TEST A2 FRENCH SPEC. GASOLINE
TEST A3 GERMAN SPEC. GASOLINE
TEST A4 NAVY MOTOR BOAT AND ADDITION OF HEAVIER OIL
GRAVITY
VISCOSITY AT 100°F
VISCOSITY AT 212°F
FLASH POINT
POUR TEST
ACID NO.
NOTE- READING FROM LEFT TO RIGHT THE ORDINATES ARE
1½% CONRADSON CARBON
2½% WATERS CARBON
8½% RESIDUE BY WT IN FINAL SAMPLE
4½% RESIDUE BY VOL IN FINAL SAMPLE

FIG. 4. OIL ANALYSES AND CARBON CONTENT

Leakage of the gasoline or gasoline mixture is influenced by the following mechanical or operation conditions:

(1) Piston clearance;
(2) Richness of mixture;
(3) Improper ignition;

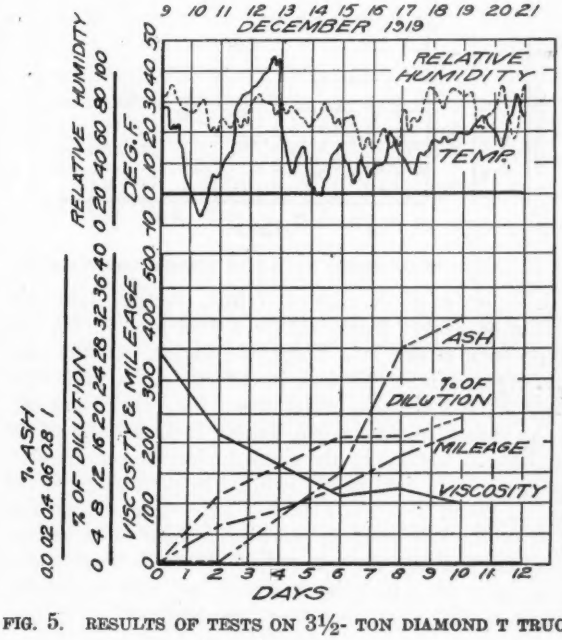


FIG. 5. RESULTS OF TESTS ON 3½- TON DIAMOND T TRUCK

(4) Operating temperature of motor affected by weather;
(5) Body of lubricant or thickness of film on walls of cylinders;
(6) Condition of cylinder walls;

(7) Condition of piston rings as affecting their all-around fit in the grooves and against the cylinder walls;
(8) Intermittent operation;
(9) Priming and using the choker when engine is cold in starting;
(10) Choking when overloading;
(11) Character of fuel;
(12) Carburetor out of adjustment;
(13) Vacuum System out of adjustment.

Losses Caused by Dilution

The losses are of four kinds:
(1) The loss of fuel
(2) Loss of power
(3) Wear of all parts
(4) Loss of lubricant.

Loss of Fuel

This loss is not entirely due to the heavy end of the fuel or to the present heavy character of the fuel,

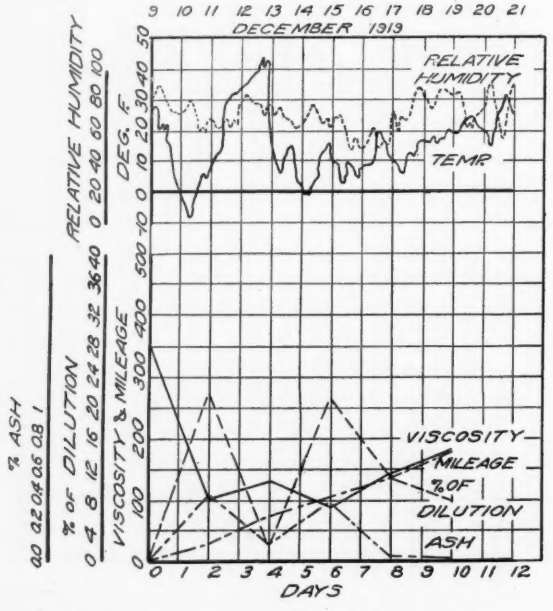


FIG. 6. RESULTS OF TESTS ON 5-TON PIERCE-ARROW TRUCK

as, irrespective of the nature of fuel, whether light and volatile or heavy, there will be a fuel loss during the compression stroke in a four-cycle engine. In the case of heavy-end fuel this loss is reflected to a magnified extent in the dilution effect upon the lubricating oil. In the case of a very much lighter fuel, say one of 72 deg. Baume, the loss by the rings during the compression stroke would be just as pronounced in percentage of the amount taken into the cylinder, supposing the sealing effect of the lubricant on the piston rings to be always the same, but the effect would not be as noticeable due to the lubricant's inability to absorb and hold the lighter fuel as a diluent at operating temperatures.

Loss of and Through Lubricant

The first effect of dilution is upon the viscosity or body of the lubricating oil, reducing this to a point where it cannot be considered efficient for a motor. This causes three conditions, which can be stated:

1. Loss of lubricant.
2. Loss of power.
3. Wear of the machine.

The first effect is the wastefulness of the lubricant, as the entire loss of lubricating oil in an internal combustion engine is caused by the lubricant creeping up the cylinder walls, mainly during the first cycle or admission stroke, and being later consumed in the combustion chamber. The lighter the oil is in body, the greater will be this loss. Further, there is another loss that is due to the present condition of dilution and the attempts made to offset this, and that is by the removal of lubricating oil from the engines at periods of from 300 to 800 miles, instead of the former periods of double this mileage, this mixture being thrown away.

Loss of Power

The basic rule in lubrication is illustrated best by considering the power necessary to operate a machine composed of a number of bearings. If the machine is lubricated perfectly with oil of the proper viscosity, the power will be at a minimum and speed at a maximum, and there should be practically no wear on the bearings. If, however, an oil of double or treble the viscosity is used as a lubricant, the power necessary to move the machine at the same speed will have to be materially

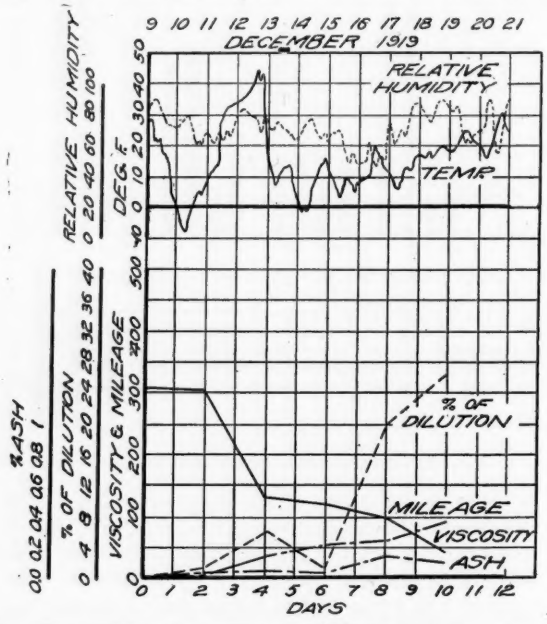


FIG. 7. RESULTS OF TESTS ON 3½-TON PACKARD TRUCK

increased, due entirely to the fluid friction of the lubricant itself. Under this condition there will be practically no wear, as the surfaces will be kept well apart. Attempting to lubricate the same machine with an oil that is entirely too light or thin for the work will also require the development of practically as much or even more power than in the case of the extra heavy oil, the resistance being due to metallic or solid friction, one of the results of which is, of course, abrasion with constant changing of the surfaces.

A lubricant actually working in a motor should have a body equal at least to that possessed by a new heavy spindle oil (130 sec. viscosity at 100 deg. F.), and an

oil of such light body must be used in a forced-feed system where the pressure and constant flow of the oil will make up for its lack of thickness of lubricating film.

As a matter of fact, under present conditions of operation, most motor oils when in an engine, in the winter especially, are much lighter than a lubrication engineer would ever think of applying to the lightest piece of machinery he would be called upon to lubricate, which is a light spindle in a textile mill. The result, therefore, of the lubrication of an automotive engine with a mixture of lubricating oil and heavy ends of the gasoline having a viscosity below that required for a textile spindle can only result in excessive wear, and this is shown by the ash remaining from the complete distillation of the sample of mixture taken from the motor.

Effect of poor lubrication is indicated to some extent by the readings of ash. These readings were taken on each sample and represent the total amount of ash in that particular sample. The ash is made up of oxide of iron, other metal, and of silica, the iron and other metal being from natural or unnatural wear of the engine, the oxide of iron coming from the water that has been in contact with the metal, and the silica coming from road dust, though at the time of the year this particular test was made the streets were well covered with snow and but little road dust could be expected to enter the engine through the carburetor or breather holes.

The wear of the machine is reflected in repair bills, in the necessity for reboring cylinders, refitting rings, when an engine becomes noisy and when compression is lost.

ANNOUNCEMENT COMES from Oil City, Pa., that according to annual review of Oil City Derrick, made public Feb. 12, oil production in United States during 1919 was 366,255,611 bbl., an increase of more than 24,000,000 bbl. over the previous year.

Did Zone Distribution Affect Coal Production?

TABLES recently compiled by the Geological Survey show the estimated production of bituminous coal in 1919, by states, with comparative figures for the years 1917 and 1918. While statistics of this sort are always interesting, these seem particularly so because they indicate to a certain extent what the effect of zone distribution of coal during the war had upon the production in different states.

To bring out this effect more clearly, the columns headed per cent have been added. This percentage is that of the total produced for the year. Three other columns have also been added in which are indicated the increases in percentage production in 1918 and 1919 over 1917 and 1918.

As will be recalled, during a good share of the year 1918 the zone system of distribution was in effect, and it was the contention that this system would tend to increase production in those states where the lower grades of coal predominate; also that once these lower grades of coal were used and their success demonstrated, the demand for them would increase, due to their lower cost.

ESTIMATED PRODUCTION OF BITUMINOUS COAL IN 1919, BY STATES, WITH COMPARATIVE FIGURES FOR 1917 AND 1918

State	1917		1918		1919 (Estimates)		Increase 1918 over 1917	Increase 1919 over 1917	Increase 1919 over 1918
	Tons	Percent of Total	Tons	Percent of Total	Tons	Percent of Total			
Alabama	20,068,074	3.63	19,184,962	3.31	15,230,000	3.32			.01
Alaska	53,955	.01	75,606	.0126	53,000	.0114	.0025	.0014	
Arkansas	2,143,579	.366	2,227,369	.384	1,680,000	.366			
Colorado	12,483,336	2.26	12,407,571	2.141	10,100,000	2.23			.089
Illinois	86,199,387	15.62	89,291,105	15.4	64,600,000	14.132			
Indiana	26,539,329	4.82	30,678,634	5.28	20,500,000	4.47	.046		
Iowa	8,965,830	1.62	8,192,195	1.41	6,300,000	1.375			
Kansas	7,184,975	1.32	7,561,947	1.305	5,750,000	1.255			
Kentucky	27,807,971	5.06	31,612,617	5.45	28,500,000	6.22	.39	1.16	.77
Maryland	4,745,934	.858	4,497,297	.775	2,970,000	.648			
Michigan	1,374,805	.248	1,464,818	.253	930,000	.203	.005		
Missouri	5,670,549	1.03	5,667,730	.971	4,060,000	.885			
Montana	4,226,689	.765	4,532,505	.783	3,300,000	.72	.018		
New Mexico	4,000,527	.725	4,023,239	.695	3,170,000	.691			
North Dakota	790,548	.143	719,733	.124	750,000	.164		.164	.04
Ohio	40,748,734	7.38	45,812,943	7.93	36,050,000	7.64	.55	.26	
Oklahoma	4,386,844	.794	4,813,447	.83	3,200,000	.697	.036		
Pennsylvania	172,448,142	31.3	178,550,741	30.9	145,300,000	31.643		.343	.743
Tennessee	6,194,221	1.126	6,831,048	1.18	5,150,000	1.123	.054		
Texas	2,355,816	.427	2,261,135	.39	1,600,000	.349			
Utah	4,125,230	.747	5,136,825	.886	4,570,000	1.	.139	.253	.114
Virginia	10,087,091	1.835	10,289,808	1.77	9,500,000	2.075		.35	.305
Washington	4,009,902	.744	4,082,212	.705	3,100,000	.676			
W. Virginia	86,441,667	15.654	89,935,839	15.5	75,500,000	16.535		.881	1.035
Wyoming	8,575,619	1.555	9,438,688	1.63	7,100,000	1.55	.075		
Other States	161,820	.029	95,806	.0165	100,000	.0218			.0051
Total	551,790,563		579,385,820		458,063,000				

Examining the figures from the states showing the greatest changes, we find that Alabama shows a decline in the tonnage produce in 1918, compared with 1917, which is also a decrease in its percentage of the total production. This decline is more marked in 1919 than in 1918, yet the percentage in 1919 is practically the same as in 1918.

Alaska shows a marked increase in production and percentage of the total in 1918 over 1917, but in 1919 the production fell somewhat below that of 1918, yet the percentage of production is greater.

In Arkansas the tonnage production was increased in 1918, but the percentage remained nearly the same,

while in 1919 a marked decrease in both production and percentage is noted.

The relative production in Colorado has remained practically the same throughout the 3 yr., while in Illinois a marked decrease is noted in both production and percentage for 1919. The same is true of Indiana, Iowa and Kansas, all of which should have been helped by the zoning system.

Kentucky, on the other hand, shows a decided increase both in production and in percentage during 1918 which continued during 1919, while Maryland, Michigan and Montana advanced their ranks during 1918, but fell back again in 1919, even below their 1917 rankings.

Ohio also furnished a larger percentage in 1918 than in 1917, but it maintained practically the same rank in 1919 as in 1918.

Pennsylvania and West Virginia, two of the most important coal producing states, have held their percentages very closely, with a slight dropping off in 1918 which was apparently due to the zoning system.

It would undoubtedly be unjust to attribute all of the changes in percentage of production to the zoning system, nor can we judge from these figures what the effect of zoning would be if continued permanently; but certainly the effect on production of the system as it was inforced during 1918 was practically nil, as evidenced by these figures, particularly those from Pennsylvania, West Virginia and Illinois, the three states that furnish more than 60 per cent of the total production.

Starting Up After a Shut-Down

By L. Williams

IT TAKES a cool-headed operator to start a plant quickly after a complete shut-down. The main difficulty is that operators worry over the service interruption so much that it may interfere with their successful handling of prime movers and switchboard. The following happened in a hydroelectric station with five 1250-kw. generators serving important mining and lighting loads over 6600- and 66,000-v. lines.

When an insulator failed on the high tension bus, it caused a short circuit which the operator could not isolate because the ground current flowed along a d.c. bus conduit setting up a surge, which caused an arc on this bus, which caused the control bus breaker to trip open.

The operator then opened the voltage regulator shunt switches, generator field switches, and exciter breakers, according to his instructions when a short circuit could not be cleared with the oil switches. This method had been decided on beforehand. When the regulator shunt switches were opened, the exciter voltage would drop to a very low value, relieving the equipment of that high short-circuit current. The five exciters on the same shaft as the generators were not disconnected from the exciter bus until the generator field switches were opened, for the reason that the generator field winding might puncture when the circuit is broken and no field discharge resistance is cut in.

Well done so far, but this is the switchboard operator's first experience with a dead station, and the flash had been so blinding in a transformer compartment adjacent to the switchboard gallery that he must do a little investigating before starting up, as he is of the opinion that a good deal of damage is done.

In the meantime the chief is running the quarter mile from his house to the plant. When he arrives the plant is in total darkness and the switchboard operator informs him of the location of the trouble. The chief then closes the d.c. control bus breaker and adjusts the voltage roughly, as it is at a low value, being obtained from a flywheel motor generator set.

He then opens all the generator and line oil switches excepting, of course, the station feeder switches. Next he gets one generator on the bus, thereby lighting the plant. Then he cuts in the Tirrill regulator, after which he closes the two 6600-v. line switches, which load this machine immediately.

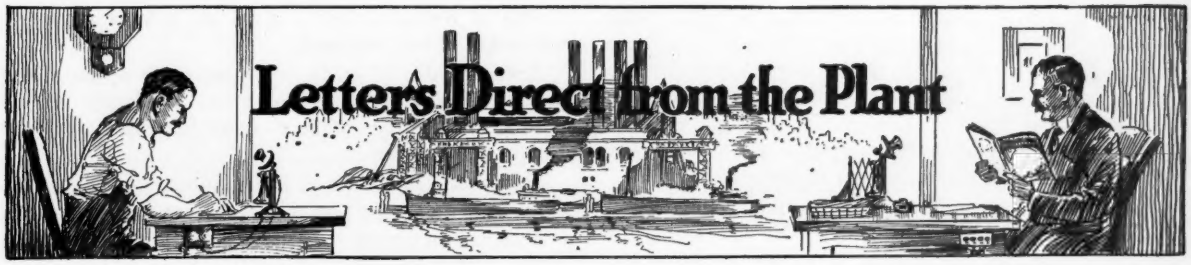
Another generator is synchronized and the two 66,000-v. lines are energized through the bank of transformers on the opposite side of the building, from where the arc appeared. As all five machines were loaded under normal load conditions, the chief was taking a chance when he energized all the lines with only two machines on the bus. He figured, however, that he could synchronize the three remaining machines as fast as the attendants at the mines would start their motors. This was true, but, figured close, as the last three machines were synchronized when the loaded machines were running at about 53 cycles, 60 cycles being normal frequency.

The graphic records showed that the 6600-v. feeders were dead 7 min., while the 66,000-v. feeders were dead 8 min. Considering the chief's quarter-mile run, better time could hardly be expected in resuming service.

Credit must be given the turbine operator for closing the main pressure valves on all governors as soon as the plant was dark. This prevented the governors from using the oil in the pressure tanks, which could not be pumped back again, as the motor-driven pumps had stopped. When he saw that the chief had one machine connected to the bus, he opened those valves again, assuming governor regulation.

UNDER the present conditions when the demand for fuel is abnormally high, the extraction of the highest percentage of total available coal in the progress of mining is a problem of vital importance. The Engineering Experiment Station, in co-operation with the Illinois State Geological Survey and the United States Bureau of Mines, has undertaken an investigation of the subject and has made a somewhat elaborate study of the facts and of the compiled information. An investigation of the percentages of coal extracted and lost in Illinois and in other bituminous coal mining districts showed that the percentage obtained is less than is commonly believed, averaging only about 50 per cent. This conclusion has led to the study of the panel system of coal mining, in order to determine the greatest possible extraction with different dimensions of working. Previously, other investigations of a similar nature have been made to determine the relation between dimensions of workings and amounts of extraction; but, so far as is known, no study of the panel system in general with regard to the percentage of extraction and the change of this percentage with the change of dimensions of workings has hitherto been made.

The results have been published by C. M. Young, Assistant Professor of Mining Research, in Bulletin No. 113 of the Engineering Experiment Station, Urbana, Ill.



Operating the Hvid Engine

BEING the owner and operator of a Hvid engine as described in Power Plant Engineering of Feb. 1, I thought I would give the readers a little practical information.

The Hvid engine has reached an astonishing degree of improvement over the regular gas engine. The one I have, a 5¾ by 9-in. unit running at 375 r.p.m., develops about 7 hp.; it replaced a 6 by 10-in. regular gas engine with mixer, sparker, hit-and-miss governor, using engine distillate as fuel. The load being steady, I had to make several minor changes to the Hvid engine; it had a hopper cooler holding 10 to 12 gal. of water. After 30 min. of running, the water would be boiling, and I had trouble with the lubrication (I tried several cylinder oils). The boiling water dissipates heat, but not fast enough for a steady load, so I made a plate held with cap screws to fit over the hopper opening and installed a regular thermo-syphon with a ½-in. pipe coming at the bottom and ¾-in. out from the top, connected to a 300-gal. tank.

As the engine had a spring grease cup at the crank end of the connecting rod which was very unsatisfactory, I installed an oil cup on the oil guard and a wiper on the connecting rod. The wristpin was not getting oil enough, so I made a groove on the top of the piston to collect more oil. The wristpin bushing is made of hardened steel with no adjustment. As soon as lightly worn, it must be replaced; as everyone knows, wristpin play will result in a wreck. It should be a great improvement if the bushing would be adjustable to the extent of 1/32 in. The connecting rod and bushing could be sawed at the upper part and held by a strong bolt. The connecting rod bearing was made of babbit liners and had to be tightened oftener than once a week; I replaced one-half with a bronze one, the babbit being too soft for the pressure.

The piston rings have never given any trouble, as I take the piston out every two weeks to clean the carbon; a little will accumulate and the clearance being so small, it is better to keep on the safe side. Every two months I move the piston rings back one groove, putting a new one in the first groove (crank end), the last one, being nearest the combustion chamber, having done its work. You may think it quite an expense, but they are plain bevel-cut rings costing little over half a dollar each and could be dispensed with by using leak-proof rings.

As fuel, I use what I have on hand, either coal oil, distillate, but mostly "tops" (low-grade distillate). Coal oil gives the best results, less carbon and better lubrication. "Tops" is the cheapest, but requires more and gives carbon. As a gallon of fuel lasts 2½ to 3 hr., this is where this engine has superior economy.

The fuel injector has never been taken off, so I can say that carburetor and sparking troubles have not worried me; this is a weight off my mind.

When I received the engine, I made timing marks on the flywheels and can examine the timing in a few seconds.

To start the engine, I open the fuel valve 1/5 of a turn, release the intake valve with one hand and crank the flywheels; after 8 or 10 revolutions, let go the intake valve and it is running. When the temperature is below 50 deg., I put warm water in the hopper so I don't have to crank twice; it is an easy starting engine. There is no bulb to heat and no compressor as on the Diesel. It is 25 yr. ahead of the common gas engine.

CHAS. LABBE.

Tilting Trap Troubles; Water Hammer

AT ONE time I had a peculiar experience with a tilting trap used for returning the condensate from the heating system to the boilers. One day this trap would

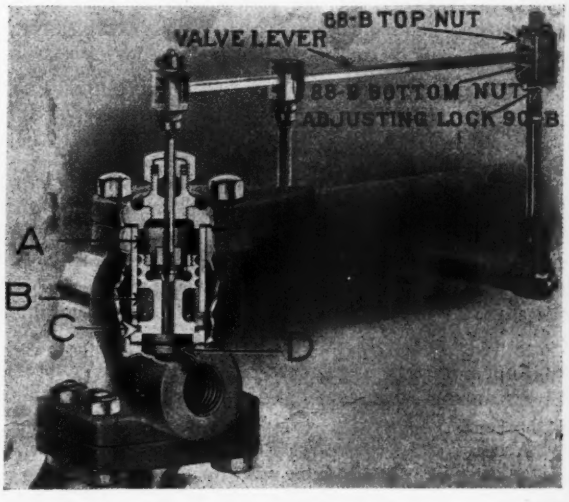


FIG. 1. TYPE OF STEAM AND EXHAUST VALVES ON TRAP

not operate as it should; it seemed as if no water would run into the trap tank from the receiver. At first I thought that perhaps the pipe leading from receiver to trap was clogged up but in taking them apart they were found clear. Looking further for the trouble, I found that the valve adjusting nuts on the exhaust or vent valve, on the trap, had moved to such an extent that there was little motion to the valve lever to open the exhaust or vent valve. This would not allow the pressure in the trap tank to be released, with the result that no water would run into the trap tank.

The reason I did not think there was anything wrong

with the steam or exhaust valves in the first place, was, because there is an adjusting nut lock over these nuts as shown in Fig. 1, which made one think there was nothing wrong as the lock was in place. When examining these parts closely, however, I found that the lock was bent apart by something striking it in some way and allowed the nuts to move out of their place.

In the main steam line of a heating system water hammer occurred quite frequently. No one seemed to know or could find the trouble, when my attention was called to the matter. In looking over the heating system I had each radiator and steam coil shut off and turned on individually. A few minutes after shutting off the last radiator, which was connected to the end of the steam line there was water hammer in the pipes. Looking further for the trouble, I found that it lay in the condensation of steam in the pipe between radiator connections a and b whenever the radiator on the end of the line was shut off, which was quite often during the day. To remedy the trouble, a small steam trap was

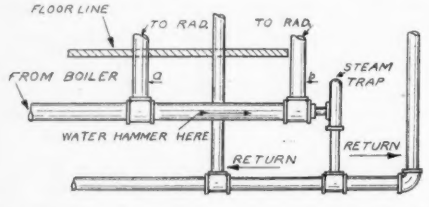


FIG. 2. METHOD OF PREVENTING WATER HAMMER IN HEATING SYSTEM

placed at the end of the steam line as shown, connected into the return pipe. This kept the pipe clear of condensation, and there was no further noise.

H. A. JAHNKE.

Safety Valve Rules

MUCH has been said in the columns of Power Plant Engineering about the National License for Engineers. So far nothing has been said about a standard safety valve rule whereby we can all calculate the lever and ball as well as the spring loaded safety valve. In fact there are a lot of us who cannot calculate this most important part of the power plant equipment.

Roper gives the following rule, which is also used by U. S. Marine examiners of engineers to find weight of ball:

Area of valve in square inches × pressure in pounds per square inch × distance valve to fulcrum. (Product 1)

Weight of lever × ½ its length or center of gravity. (Product 2)

Weight of valve and stem × distance from fulcrum. (Product 3)

Add these last two products together and subtract the answer from the first product and divide by length of lever, which gives weight of ball for any size or blowing pressure.

Another U. S. Government rule for safety valves is $A = 0.2074 \times W \div P$, in which area is represented by A. W represents pounds of water evaporated per square foot of grate surface per hour. P represents absolute pressure per square inch, or gage pressure plus 15.

One of Swingle's books gives the following rule to find weight of ball required:

Area of valve in sq. in. × pressure per sq. in. minus effective weight of valve and lever. Multiply the remainder by distance of stem from fulcrum ÷ distance of ball from fulcrum.

Hawkins' Handbook of Calculations says:

To find weight of ball—

Pressure in pounds per square inch × area in square inches. (Call this No. 1.)

Weight of lever in pounds × center of gravity from fulcrum ÷ distance in inches from fulcrum to center of valve × weight of valve and spindle. (Call this No. 2.)

Divide distance in inches from center of valve to fulcrum by distance, also in inches, from center of weight to fulcrum. (Call this No. 3.)

Subtract No. 2 from No. 1 and multiply by No. 3.

Here is what Kent gives us:

$$W = (PAl - wg - Vl) \div L$$

W = weight of ball.
w = weight of lever.
V = weight of valve and spindle.
L = distance from fulcrum to ball.
l = distance from fulcrum to center of valve.
g = distance from fulcrum to center of gravity of lever.
A = area of valve in square inches.
P = pressure in pounds per square inch.

The I. C. S. has this rule:

To find the weight that must act on a lever at a given distance from the fulcrum so that the valve is about to blow off at a given pressure, subtract the downward force due to the weight of the valve, stem, and lever from the product of the area and the steam pressure. Multiply the remainder by the distance from the fulcrum to the center line of the valve and divide this by the distance from the fulcrum to the point at which the weight is to act.

Andel's Engineer Examiner says:

To find weight of fall needed, multiply steam pressure by the short arm and divide the product by length of lever.

Now, the question is, how are we going to know which is right? I believe we should have a standard rule that will apply to all cases and thereby make it a lot easier for the man going before the examiner. As it is, he is in hot water most of the time. R. G. SUMMERS.

Figuring the weight of the ball required for a lever safety valve is nothing more or less than a problem in levers and weights. It is, therefore, not a question of knowing the proper rule, but of having the rule stated properly, as there can be but one rule. All of those given, with the exception of the rule for area, are presumably based on the lever problem, although those attributed to Hawkins and Audel do not produce the same answers as the other four, all of which give similar results. Those which are stated most clearly are Roper's and Kent's.

The most authentic rules for figuring the area of spring-loaded safety valves required are those recommended by the Boiler Code Committee of the American Society of Mechanical Engineers. For a bevel seated valve of 45 deg. angle the formula is:

$$A = \frac{W70}{P} \times 11$$

and for a flat seated valve

$$A = \frac{W70}{P} \times 8$$

in which A is the area of direct spring-loaded safety valve in square inches per square foot of grate surface, W the weight of water in pounds evaporated per square foot of grate surface per second, and P the pressure (absolute) at which the safety valve is set to flow.

EDITOR.

Economizer Operation

IT HAS been estimated by the rule of thumb method that if the heating surfaces of an economizer are kept clean, each drop of 2 deg F. in the temperature of the gas between the ingoing and outcoming temperatures will raise the temperature of the feed water 1 deg. F.

As an illustration of this, the following is interesting. The temperature of gases entering an economizer is shown by the recording thermometer to be 405 deg. F. and leaving, to be 200 deg. F.; hence, the drop in gas temperature is $405 - 200 = 205$ deg. F. As the water enters the economizer in this particular case at 110 deg. F., the rise in temperature from the rule should be 102 deg. and the temperature of the water entering the boilers $110 + 102 = 212$ deg. On the installation of the recording thermometer, the real temperature of the water leaving the economizer was found to be 260 deg. F., making the rise in temperature 150 deg. F. or corresponding to a rise in temperature of 15 deg. for each 20 deg. drop in gas temperature.

As each 11 deg. F. rise in temperature represents a saving of 1 per cent in fuel, the saving in this case is $150 \div 11 = 13$ per cent.

If a plant of 2000 boiler horsepower runs 8 hr. a day and including auxiliaries the coal per horsepower hour is 4.25 lb. with coal at $5 per ton delivered and an economizer cost of $9200 including induced draft apparatus, the following might be expected. $2000 \times 4.25 \times 8 = 68{,}000$ 68,000 lb. of coal a day, at a cost of $\frac{68{,}000}{2240} \times \$5 = \$150$.

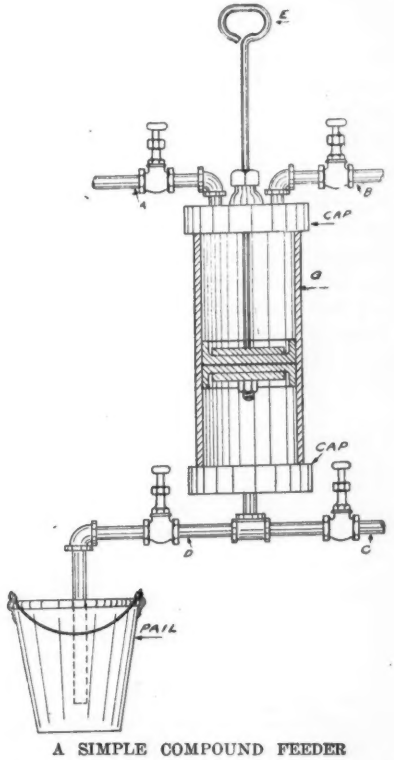
If calculations show 13 per cent saving as above we will have $\$150 \times 0.13 = \$19.50$ per day and 300 days in a year equals an annual saving of $19.50 \times 300 = \$5850$.

Allowing 15 per cent of the cost for interest repairs and depreciation, it will be 15 per cent of $\$9200 = \$1380$, we shall have a net savings of $\$5850 - \$1380 = \$3470$, or at the rate of $3470 \div 9200 = 37$ per cent on the investment.

RECEIVER.

Boiler Compound Feeder

A SIMPLE and easily made boiler compound feeder is shown in the sketch herewith. The body, G, is a piece of extra heavy iron pipe bored out smooth and true and capped on both ends. The plunger is made from two heavy iron washers, threaded in the center to take the ⅜-in. brass rod, E. Two cup leathers are used between the iron washers. The maker claims that the soda in the compound has little effect on the leathers. The caps are drilled and threaded to take the stuffing box and pipes required. Valve B connects to full pressure steam; C to boiler feed water; A is a waste pipe; D is the filling pipe. To fill G, press down on E until the plunger is at the bottom, valves B and C being closed, and A and D open. Place the liquid compound in the pail and pull the plunger to the top; this fills the chamber. Valves A and D are now closed, valve B is opened wide and valve C opened slightly.



A SIMPLE COMPOUND FEEDER

This feeder must be set several feet above the water line of the boiler, which would be a considerable drawback in a good many plants. The height of the ring, E, shows the height of the compound in the chamber. C and B are ¼-in. valves and A and D are ¾-in.

JAMES ELLETHORN.

Steam Traps

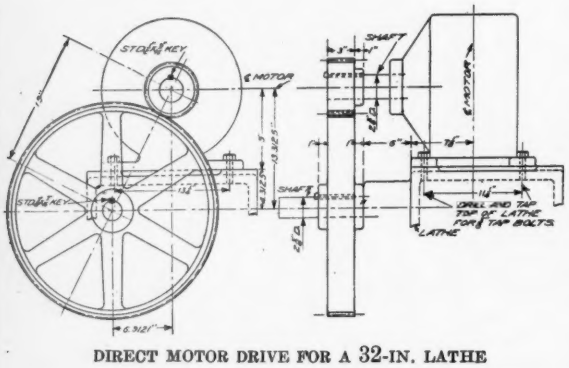
IF A TOTAL census were compiled, I am afraid that the number of traps tabulated in almost any plant would not only startle the operator, but would amaze those interested in features of steam engineering, and if an inspector of steam piping were put on the job to correct this trouble, his task would be as great as attempting to overhaul a completely dilapidated steam institution in one week which it would take a year to do properly, and why is all of this trouble? Only because it is an old habit when we are confronted with the trouble of condensation that we stick a steam trap into service, accepting it as a necessary evil, and then in many cases not only leaving it to its own fate, but also in forgetting in what location of the line it is placed. I admit it to be a fact that steam traps when properly placed are a big money saver; but they are installed in

many instances without the proper consideration, and if we will dig down just a little deeper into our troubles, I am sure it will be found that about 75 per cent of them can be dismissed and sold for old junk or to the second-hand dealer, and all because our pipe lines leading from the boiler room are not correctly installed. Every pipe line, regardless of length or size, should have an incline back toward the boiler room, and all pipes branching off from any line should not take their supply from the side or bottom, but from the top of the line, and in that case you will not acquire any condensate unless a line is overloaded at times, and if that is found to be the case the correction should be made by the drainage system of evaporation back into the boilers, resulting not only in a saving in the fuel bill, but possibly an increase in the engineer's salary. H. W. ROSE.

Motor Drive for Lathes

IN ORDER to speed up production in industrial establishments, engineers are often called on to design direct motor drives for machines which were installed, in many cases, before the mad rush struck us a few years ago.

I am showing herewith a sketch of a direct motor drive which I installed on a 32-in. lathe in the repair department of a steel works.



DIRECT MOTOR DRIVE FOR A 32-IN. LATHE

In this particular case the motor was mounted on top of the lathe and secured by means of four ⅝-in. bolts in the manner indicated. Both pinion and gear are of rawhide, the former with 36 and the latter with 144 teeth. G. W. CHILDS.

Back Pressure on Compression Systems

IN THE issue of Jan. 15, there is an interesting article by A. G. Solomon on the subject of back pressure on compression systems. I do not agree to all the statements made. In the opening paragraph the big interrogation is "how do you control the back pressure on the system?" In the middle of the first column on page 149, he says, "The back pressure carried on the evaporating coils is governed by the temperature of the brine or room in which the coils are placed." That is true, provided the discharge valve from the coils is closed, but so long as the suction line is open to the compressor and the compressor is operating, the back pressure on any system depends upon the rate at which the ammonia vapor or gas is removed from the system by the compressor. In other words, the back pressure is controlled by the speed of the compressor or the number and size of the compressors in operation.

If the back pressure is regulated or attempted to be regulated by the amount of liquid put into the expansion coils through the expansion valves, the compressor will always be in trouble, either too hot or too cold and never quite right.

The question, "What is the proper back pressure to maintain on a system?" can be answered only in a general way. From the standpoint of the man who is operating a plant already in operation, the answer should be, "The highest back pressure which will give the desired results." The method of determining the theoretical pressures has been clearly stated by Mr. Solomon; but as every operator knows, conditions are never maintained as set down on paper.

When material is being stored in certain coolers more rapidly than usual, there may not be compressor capacity sufficient to keep down the back pressure. In that case, it has been my custom to give those coolers as much liquid as the coils will evaporate and let the back pressure rise. This may allow the temperature in some other cooler to rise slightly; but if no harm is done thereby, the coolers, being filled with warm material, can be more quickly brought to the desired temperature. If the back pressure is held down by pinching off on the liquid to the coolers being filled; then the compressor will begin to run hot and cause trouble.

In operating a refrigerating system, it must be borne in mind that the higher the back pressure the greater the efficiency of the compressor and therefore the lower the cost of refrigeration.

Coolers in which a temperature of less than 20 deg. F. is desired should be connected to a separate suction line and connected to a separate compressor or separate working units of a compressor. In this way, a low back pressure does not have to be carried on the parts of the system where it is not necessary.

My two general rules are: (1) Regulate the back pressure by the speed of compressor or rate of compression. (2) Regulate the temperature of the compressed gas leaving the compressor by the expansion valves in the system.

In the flooded type of compressor, the gas leaving the compressor may be as hot as 130 deg. F. with good piston rods and packing; but the packing must be watched, as the soft packing swells quickly and binds the rod. When the rod starts to warm up, ease back slightly on the gland, provided you know there are threads enough.

It is impossible to run all the coolers in the same way. The brine system (if there be one) will usually determine the back pressure to be carried. In that case, give the brine cooler expansion valve about all the liquid the brine will evaporate; that is, keep this coil flooded without having an excess of liquid going over with the gas. Some coolers will not stand a flooded coil, as the temperature would drop too low. In that case, regulate the temperature in these coolers by the amount of liquid through the expansion valve. This will give a superheated gas discharge from these coils. There are usually one or more coolers which are always a bit too warm because of too small an expansion coil or excessive use of the cooler and it is on these coils that I rely in regulating the temperature of the compressor.

An excess of liquid will not lower the temperature below that desired and if the coil is short and already

flooded, a little more liquid through the expansion valve will pass quickly back to the compressor.

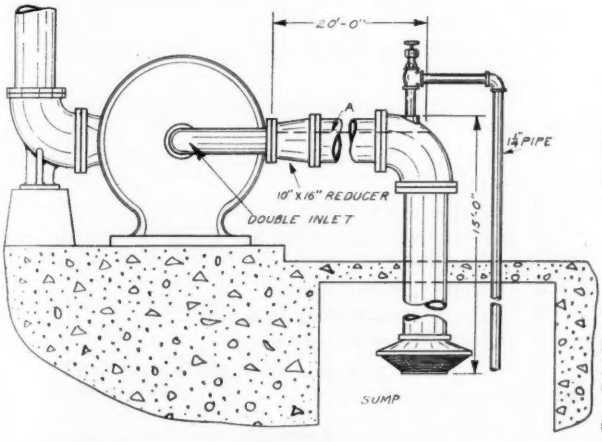
In some cases, there is a liquid line connected into the suction line near the machine, in which case it is not necessary to give any expansion coil an excess of liquid, as the temperature of the machine can be regulated at the compressor. C. E. MOULSON.

Overcoming Centrifugal Pump Troubles

IN READING Power Plant Engineering, copies of which I find in the several power plants I visit, I like to turn to "Letters Direct from the Plant." Sometimes it reminds me of my own troubles. I am sending one of a pumping plant that failed.

We had just finished coupling up two 2000-gal. centrifugal pumps to handle the water for the coal washer, when the boss came down in the pump pit and demanded a tryout.

The 16-in. suction lines ran horizontally from the pump platform to the sump for 20 ft., then elbowed down. The sump was connected to the dam 200 yd. away by 24-in. tile below water level.



REDUCER IN SUCTION LINE MAKES AIR POCKET

One pump was primed with a hand pump until the suction and pump was full. Examination showed no leakage anywhere.

The motor was started and the pump took the load nicely for about 5 min., then the vacuum gage began to fall. At 10 lb. it stopped for a time, then moved to 9, then back to 10 again.

Seeing the strange actions of No. 1 under seemingly good conditions, the boss ordered No. 2 started, with the same result; both vacuum gages reading practically the same.

After a great deal of examination it was decided that air collected in the suction line and gradually choked off the supply.

It was a case of exhaust the air out of the suction with another pump or find a cheaper way, which we did.

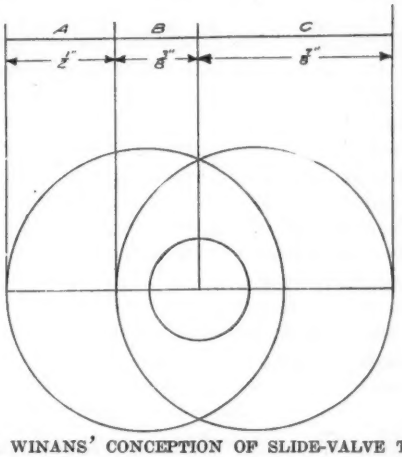
We tapped the ell on top, which was the highest part of the line, and ran 1¼-in. pipe down in the sump, thus giving the pump a chance to move the air at A and filling the space with water.

The pumps are working today with the same sort of connection we put on 4 yr. ago. J. P. BERRY.

Unusual Conception of Slide Valve Travel

IN THE Oct. 15 issue, I note a statement that, "the travel of the slide valve is the total distance traversed during one revolution of the eccentric. This is equal to twice the eccentricity of the eccentric."

It is an error to presume that the eccentric is only a shaft with an enlarged crankpin. I am enclosing a graph showing an eccentric in the two opposite positions. Note the distances A, B and C. Distance C is



ROY R. WINANS' CONCEPTION OF SLIDE-VALVE TRAVEL

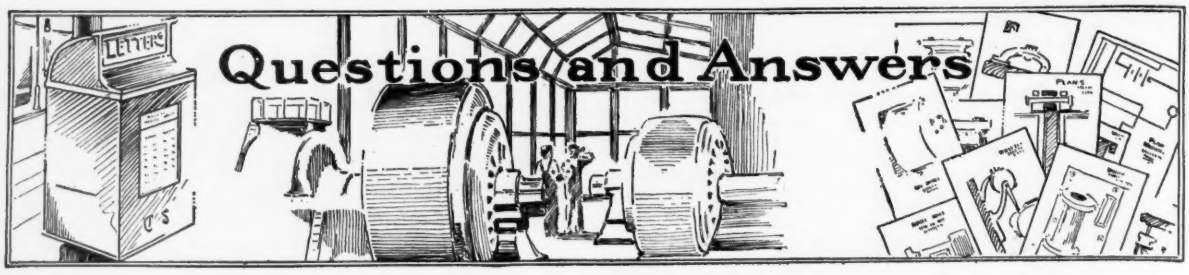
the maximum from center of shaft, or ⅞ in. distance. Distance B is the minimum, ⅜ in. Subtracting B from C gives us the eccentricity, or ½ in., which is also the total valve travel shown at A. ROY R. WINANS.

Blowoff Pipe Failure

AT ABOUT 5:30 p. m. the bottom blowoff pipe gave way at the elbow. The boiler had 90 lb. gage and ½ glass of water. The writer, who was in charge, had just left the boiler room to look over the refrigeration plant. The elbow, as well as pipe, was not protected from hot gases and flame. The fractured elbow was put on a year ago. There were no fatalities, but the soot and dirt flew all over the place. The blow opened both fire doors and blew out the fire. An examination of all blowoff piping showed everything clear, as the boiler is blown every day.

R. G. SUMMERS.

U. S. CIVIL SERVICE COMMISSION announces an examination, March 17, for automatic scale expert, to fill a vacancy in the Customs Service, New Orleans, La., at $1600 a year, and vacancies in positions requiring similar qualifications throughout the United States, at this or higher or lower salaries. Appointees whose services are satisfactory may be allowed the temporary increase granted by Congress of $20 a month. Competitors will be examined in the following subjects: Practical questions; report writing; arithmetic, including fractions, weights, and measures; training and experience. Applicants must have served at least 3 yr. in a workshop as an electrician's apprentice, and thereafter must have devoted not less than 2 yr. to machine work involving the construction and care of high-grade machinery or instruments, or must have had equivalent training and experience. Apply for Form 1312.



How Do You Account for This?

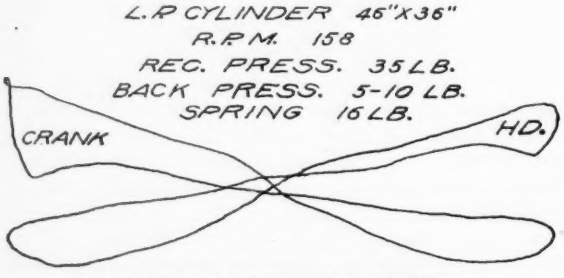
WE HAVE a condition in connection with our steam turbine installation which is peculiar and which we haven't been able to solve.

We operate a power plant providing current for light, power and railway service. As the lighting load comes on in the early evening, the vacuum rises, say from 2 in. absolute to 3½ in. absolute and within a half hour drops about two or three-tenths of an inch, load remaining the same.

We have been searching for the cause of this rise, but have been unable to locate it, and would appreciate getting readers' views so that we may locate the difficulty. W. P. C.

Why Does the Bearing Heat Up?

THE CARD shown was taken from the low-pressure cylinder of a 29¼ by 46 by 36-in. Erie City cross-compound engine. I am having trouble with the low-



CARD FROM LOW-PRESSURE CYLINDER

pressure main bearing and two eccentrics running hot. Can any reader tell me the reason for this? X. Y. Z.

Peculiar Engine Performance

D. G.'s ENGINE TROUBLE as related on page 208 of the Feb. 1 issue may, in all probability, have been caused from quite a number, or at least from one, of the many ailments of the steam engine. First, if the engine had not been well heated up as to cylinder, and valve gear combined with plenty of oil upon all of its bearings, that condition could have developed the pound by the steam condensing, the engine not being hot or the valves may not have been in operation long enough to have worked themselves thoroughly free from the lubricating oil which is fed them, and the cylinder from the lubricator.

I am of the opinion, however, from the alteration which was made upon the piston rod at its crosshead connection that the original trouble which caused this knock is due to the fact that the piston rod either worked itself out of the crosshead while the engine was in operation or the quarter box main crank shaft bearing upon that side of the shaft most likely had worn, and worn with other loose bearings of the crosshead and crankpin which permited the piston rod to travel that additional distance until it touched the cylinder head.

It is a mighty good rule to look an engine over carefully before you start it out on its regular run, and at the same time allow it to turn over at quarter speed for about 5 min. before the load is put on. H. W. ROSE.

Elevator Questions and Answers

WILL YOU please favor me with answers to the following questions?

1. Describe how you would go about inspecting an elevator.
2. What is the most common defect of passenger elevators?
3. What is the most common defect of freight elevators?
4. Describe the plunger elevator.
5. Describe what accidents are liable to happen with plunger elevators.
6. Describe automatic gates.
7. Describe semi-automatic gates.
8. Describe inter-locking gates.
9. How would you determine the proper load to be allowed on an elevator? T. F. M.

ANSWERS

YOUR first question is a rather broad one and can hardly be covered fully in a letter. We will say, however, that before attempting to inspect an elevator, one should become thoroughly acquainted with the type of elevator one is about to inspect. Some points which require particular attention are the safety appliances, the cables, and the propelling mechanism dependent upon the type of elevator.

2 and 3. We cannot say what is the most common defect on passenger or freight elevators, but we believe it to be the failure of the safety devices and deterioration of the cables in a cable elevator.

4. The plunger elevator consists essentially of the cage mounted at the upper end of a plunger, which works in a cylinder set below the level of the ground. As might be expected, it is necessary to have this plunger slightly longer than the desired height of the elevator lift. This type of elevator is operated by the admission of water under high pressure into the cylinder, causing the plunger to elevate the car, while the descent is caused by allowing the water to be forced from the cylinder by the weight of the car and plunger which descend by force of gravity.

5. The accident most likely to happen to a plunger elevator is the separation of the car from the plunger itself. If this should happen, the counter weights attached to the car would carry it to the top of the shaft, no doubt breaking the cables connecting the two. The elevator would then fall to the bottom of the shaft, as plunger elevators are not equipped with safety devices.

6. The automatic elevator gate is one which automatically opens as the car reaches the floor at which it is to stop and automatically closes as the car leaves the floor.

7. The semi-automatic gate is one which requires to be opened manually but closing automatically as the car leaves the floor.

8. The interlocking gate is one which is kept locked at all times, except when the car is at its floor.

9. The safe load on an elevator of the cable type is determined by the breaking strength of the cables, allowing at least a factor of safety of ten. From this, of course, the weight of the car itself should be deducted.

Repairing a Leaky Boiler

IN REPLY to D. G.'s inquiry as to leaks in his Kewanee boiler appearing in Power Plant Engineering of Feb. 1, I advise him to try calking the leak inside of the firebox with a calking tool, which could be done in a very short time. As to the one at the rear stay bolt, he could drill a small hole. As he did not say how large a boiler he had, I could not advise him as to the size of this hole. He must use his own judgment. This hole could be drilled lengthwise of the stay bolt the thickness of the shell; then use a punch and swedge out this hole, making the stay bolt tight in the head, after which he could fill the hole with Smooth-on, which hardens very quickly.

LESLIE KLOCK.

D. G.'s LEAKS, Feb. 1 issue, page 208, can be repaired in a short length of time, first by oxy-acetylene welding the seam inside the fire box door or corking it. I believe that the welding job will prove beneficial, as it is now quite extensively practiced. The leaky stay bolt can be repaired by repening it; if that has already been attempted and has not proved beneficial, I would suggest that a new one of Swedish iron be installed, making sure that all of the threads are in good condition.

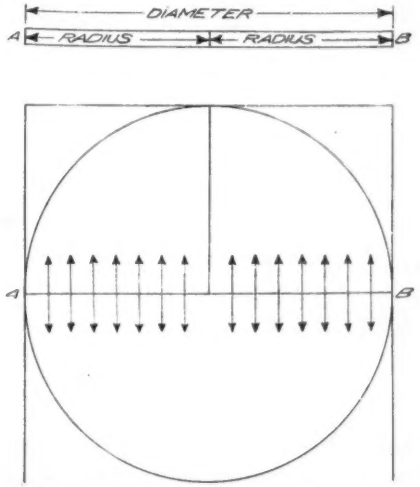
H. W. ROSE.

Who Is Right?

ON PAGE 158 of the Jan. 15 issue, Mr. Bresnahan says that in Question 1, pages 886 and 887 of the Oct. 1 issue, relative to finding the total bursting pressure along the longitudinal joint, that I use the radius instead of the diameter. He gives a formula as follows: (Diameter × pressure) ÷ (2 times the plate thickness) =pressure tending to rupture the longitudinal joint. The thickness of plate does not enter this problem; the stress on this joint is the same regardless of thickness of metal. If we were finding the safe working pressure, the thickness of metal must be considered.

Question 2. The formula he gives to find the strain on the girth seam is (area of head in square inches × pressure) divided by (3.1416 times thickness of plate). Now, with a ½-in. plate this would give about 180,000 lb. which does not look reasonable to me. My answer (area of head × pressure) ÷ (circumference of shell in inches), gives the stress for each inch around the shell. The thickness does not enter this problem any more than it does in the foregoing.

Question 5. Why do you use the radius of a shell in finding its bursting pressure? He states that it is used because the force tending to burst the shell in one direction is opposed by an equal force acting in the other direction. My reason is as follows: As we are considering the pressure in one direction only, we must consider only the area in that direction which is the area that comes crosswise to that direction, the "projected area" as it is called, the area of the shadow, cast by rays of light blowing in that direction. This is the diameter of the boiler inside and one inch high as shown in the accompanying illustration so that the number of square inches upon which the pressure is effective in one direction is equal to the diameter for a strip one inch wide. Then there is a force tending to pull each one inch ring apart, and this force is resisted by two running inches of metal, one at A and one at B. So one half of this projected area is resisted at A and the other half at B; this one half of course is the radius. This is the reason why the radius is used in the Massachusetts State Boiler Rules.



ILLUSTRATING WHY W. N. L. USES THE RADIUS IN CALCULATING BURSTING PRESSURE OF A SHELL

Question 16. This question is what would the receiver pressure be with 150 lb. boiler pressure? and has been discussed by engineers in western Massachusetts without finding a satisfactory answer. My answer I know is satisfactory to the examiner. Now, 41.25 lb. seems high; but notice that I was dealing in absolute pressures, which would leave me 26.55 lb. gage, and if you were ordering a safety valve for the receiver you would order by these figures. Then with an engine carrying 165 lb. absolute pressure with a heavy load, your receiver pressure would be high, while with light load it will be a vacuum at times. The way that is done in some plants is to equalize the work in both cylinders at average loads and let receiver pressure be what it may.

W. N. L.

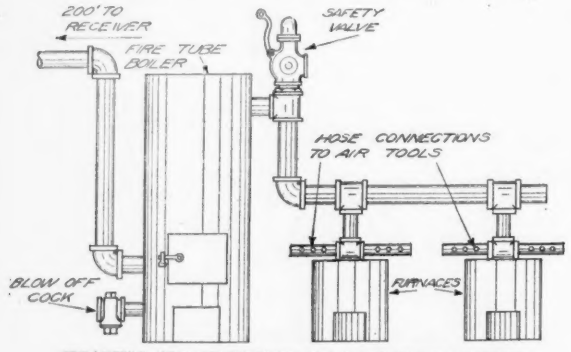
Why the Snow-Like Ice?

I HAVE READ with interest J. W. D.'s inquiry, and A. G. Solomon's reply thereto in the Feb. 1 issue, page 208.

Mr. Solomon's letter is splendid; he has covered the ground in detail. I wish to state further that, should J. W. D. not find his trouble among any of the suggestions submitted by Mr. Solomon, it would be advisable for him to consider the length of time according to the size of his ice cans that he is allowing this ice to freeze, as there may be his trouble. H. W. ROSE.

Heating Compressed Air

I THINK possibly W. W. W. could improve the air system, which he describes in the Feb. 1 issue of Power Plant Engineering. At one place where I worked a vertical fire-tube boiler, without smoke box or stack, was used as the heater, as shown in the illustration. The air came from the receiver in the boiler room 200 ft. away, passing through the heater and into a long line, from which connections were made at convenient points to short headers provided with a number of outlets for air hammers and drills. Each header was placed over an open furnace or salamander. A blowoff



HEATING AIR BY MEANS OF A VERTICAL BOILER

cock was provided on the heater for removing water.

With this arrangement, I have worked air drills and hammers when the temperature was 10 deg. below zero.

J. S. BELL.

Power Factor Correction Problem

SUPPOSE A is purchasing power from B. A's load consists of induction motors and his plant shows a power factor of 80 per cent. If A should install a synchronous motor and boost the power factor to unity, would his power bill be less? W. B. S.

A. The lower the power factor of any alternating-current circuit, the heavier will be the flow of current, and, as a consequence, the larger will have to be the conductors. The result of this is that the cost of installing the system will be considerably in excess of that of a system in which the power factor is maintained as near unity as possible. However, the machines connected to this circuit, that is the motors, will under given conditions of load have given power factor values, and as a result the energy required to operate these motors remains constant whether or not the power factor of the system is raised by the introduction of some form of power factor corrective device, such as a static condenser or a synchronous motor.

As far as the purchaser of power is concerned and aside from the fact that his system will have to be made up of somewhat heavier conductors, there is little to be gained by the correction of the power factor of the system. Companies selling electric energy are, however, benefited with an improvement in the power factor of their systems, and as a result, are generally willing to provide a somewhat lower rate for energy when they find their customers making provisions for the reduction of losses due to low power factor.

We take it from your letter that you are purchasing your energy from some central station company, and it occurs to us that it might be advisable for you to take this matter up with their engineers; we are quite certain that if they find your power factor at present exceedingly low, they will be willing to quote you a somewhat lower rate for your power on the condition that you will install some form of power-factor corrective device.

Why the Short Stroke?

REFERRING to P. W. M.'s pump trouble, page 158, Jan. 15 issue, there are many reasons for a duplex steam pump acting as his does. If he is sure he can not overcome the trouble by adjusting the steam valves, something else must be wrong.

Not long ago, I had similar trouble with a pump of the same type and make and used for boiler feeding, taking water from an open heater. One side of this pump started to work with a jerky motion which in turn caused a slamming noise in the pump and feed lines to the boilers.

As I found I could not remedy the trouble by adjusting the steam valves, I examined other parts of the pump and found that the water piston packing on this side was worn and leaked badly. The packing was removed, when the pump ran smoothly for a short time, after which the same trouble appeared. I then decided there was something wrong in either the water or steam cylinder of the troublesome side. I examined every part closely and in calipering the water cylinder, found that the brass lining was worn much more in the middle than near the ends. After replacing the worn lining, there was no further trouble. I am sure that if P. W. M. will examine the troublesome water cylinder of his pump, he will find that this is worn.

H. A. JAHNKE.

THE TROUBLE with P. W. M.'s pump is very likely in the water end. If the water pistons are packed too tightly or one jacket tighter than the other, it will cause the piston to stick until the other side has nearly finished its stroke. This causes a hammer in the feed lines.

I think if P. W. M. will set his steam valves and take a little of the packing out of the water piston, his pump will work all right. Also, the packing on the rod may be drawn too tight.

Hydraulic packing expands when used in hot water. I usually use two rings of the hydraulic and one flax. This allows for expansion and does not score the linings of the pump. W. G. WALTERS.

A Readily Solved Tank Problem

I HAVE an example I cannot get. Three pipes open from a tank, one pipe can empty the tank in 6 hr., second pipe can empty it in 4 hr., and third pipe in 3 hr. How

many hours are required for all three pipes together to empty the tank?

This tank being full, the pipe which takes 6 hr. to empty and the one taking 3 hr. to empty are working together to empty this tank, and the pipe which takes 4 hr. to empty the tank is filling it at this rate; how long will it take the 6 and 3 hr. pipes to empty the tank? This problem is no doubt easy when you see the solution. G. H. S.

A. The pipe which can empty the tank in 6 hr. withdraws 1/6 of the total quantity of water per hour. The 4-hr. pipe takes out ¼ of the water, while the 3-hr. pipe takes out ⅓. The total quantity of water withdrawn per hour is therefore 1/6 plus ¼ plus ⅓, or ¾ of the total capacity of the tank. Dividing this into one we get the time necessary to empty the tank as 1 hr. and 20 min.

Where the 6-hr. and the 3-hr. pipes are both emptying the tank and the 4-hr. pipe filling it, the total amount of water passing from the tank is equal to 1/6 plus 1/3 minus ¼, which equals ½. Dividing this into one gives the total time required to empty as 2 hr.

Will Gas Form in Storage Tank?

THE ABOVE question was asked on page 208 of the Feb. 1 issue. The problem to a reader from a mechanical viewpoint seems to be very much lacking in detailed information. Of course I am well aware of the fact that all machinery must be erected and operated to meet the duties it must perform. However, in a case of this kind where climatic conditions have to be reckoned with, the erection of an air serving apparatus could be so installed, and arranged that the climatic conditions as to the atmospheric temperature would prove of no annoyance whatsoever. The compressor and receiver could be placed in the same room, and within a few feet of one another, and if necessary thoroughly insulate receiver with 85 per cent magnesia about 2 to 3 in. thick, or some high-temperature cement which I am sure would give the results desired.

The close connection between the compressor and receiver may have a tendency to cause the air to be a least bit damper than it would be if the receiver were farther away from the compressor. This trouble to a certain extent can be eliminated by draining the receiver oftener than has been done heretofore or by installing a coil of piping of 75 to 100 ft. in between the compressor and receiver, and the discharge lines from the receiver to their place of destination could be thoroughly insulated with the same insulation which was used upon the receiver. If judgment dictated it was not enough, and steam was available, I would then first insulate my air lines with a very light common grade of asbestos covering. On top of this covering, I would then run a ¼-in. steam line strapping it every 4 ft. so as to hold it snugly to the other, and around it all I would use the pipe covering of 85 per cent magnesia or high-pressure cement. Then use a square boxing out of 2 by 4 lumber or 1½ by 4 and case up the piping out to the end where the rubber tubing then conveys it to the tools which are using it. At the end of my ¼ in. steam lines, I would place small valves, allowing them to be opened just enough to take care of the condensation and not to waste any steam more than is necessary and in this manner the desired working temperature of the air should be attained.

On all receivers, there should be a relief valve the same as on a steam boiler to take care of the excess pressures.

The reheating problem is no doubt good where the air is in constant circulation, but should the flow through the reheater be partly stopped, and the heat run up, some disastrous results are liable to occur; however, they seldom happen, yet it is unwise to take chances unnecessarily.

If I were going to use a reheater in connection with a storage tank, I should desire it to be at least 50 ft. away, and would place two check valves in the line, one close to each apparatus, then should anything happen and the one next to the reheater fail, the one next to the receiver may have time to trap the backing up ignited gases before they reach the receiver, as there should be a short length of time between the explosion in the heater and the amount of air lying in the pipe between the receiver and the reheater before all of the air in this portion of the pipe would be shoved back into the storage tank, which should give the check valve ample time to catch it before any damage was done to the receiver. H. W. ROSE.

D. C. Transmission Calculation

I WOULD LIKE you to give me the size wire required to transmit 220 v. direct-current 3960 ft; also the allowable voltage drop for a 230-v., 55.3-amp., 15-hp. motor. J. G. B.

A. To design a two-wire direct-current circuit, we may employ the following formula:

$$\text{Circular mils} = \frac{2D \times I \times 10.4}{E}$$

Where D is transmission distance in feet, I is current in amperes and E is allowable voltage drop. D is in your case equal to 3960 ft., I is 55.3 amp. and E, let us assume, 20 v. Substituting these factors in the above equation, we have

$$\text{Circular mils} = \frac{2 \times 3960 \times 55.3 \times 10.4}{20} = 227.747$$

The nearest commercial size of conductor is one of 250,000 circular mils.

This may appear as quite a heavy conductor to supply current to a 15-hp. motor; but consideration must be taken of the fact that the transmission distance is considerable, especially so for direct current work.

Pump Suction Capacities

WILL a pump located in a deep mine have a greater lift than one on the surface, assuming all joints air tight? J. H. D.

A. Due to the fact that air pressure in a deep mine is considerably greater than at ground level, a pump will lift water higher in a mine than it will at the surface.

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House Heating by Electricity

Fair-minded and well-informed engineers have always contended that open air heating of houses by electric current is impracticable both from the standpoint of economy in dollars and cents and the conservation of coal when the current is generated in steam power plants. Now comes a report of an extensive investigation caried on by the Public Utilities Commission of the State of Idaho which concludes with: "We find no grounds for holding out to the people of Idaho a reasonable hope that electricity will ever be used generally for house heating in our state, and we are forced to the conclusion that the use of electric energy for house heating in Idaho in competition with coal is neither feasible nor practical, and would be unprofitable to any producers who might undertake to furnish the service; and, further, that so long as there remains a field for the use of electric energy as motive power, its use for house heating is extravagant and wasteful."

From the standpoint of convenience in the home and the health of families, electric heating is the most nearly ideal which has yet been devised, and it is no small wonder that the people of Idaho with water power going to waste in great quantities should demand an investigation into the feasibility of using electric current for house heating. The conditions there seem ideal, for some of the hydroelectric power plants are used almost exclusively for pumping irrigating water during the late spring, summer and early fall, and during the winter go begging for customers, but the commission says it can't be done economically when a power or light load is available.

To the layman this may seem like another case of political chicanery to cheat the people out of the things they desire and give the public service corporations additional profits, but the evidence gathered by the commission is exhaustive and comes from sources which are thoroughly reliable and practically all points to the same conclusion.

A fallacy quite common among power plant men as well as those less familiar with the industry is that water power is much cheaper than steam power—in fact, that it costs almost nothing. Due principally to the high first cost of plant, it is only under the most favorable load and distribution conditions that a water power plant can compete economically with a steam turbine plant when the price of coal is moderate. This fact, conclusively proved by evidence presented before the commission, is not new to engineers who have investigated the subject, but, coming as it does from a public utilities commission of a state whose principal source of power is its water falls, the public in general will give the question more thought and perhaps be more lenient in its legislative concessions to private corporations contemplating the development of power sites.

The conclusions reached were, for the most part, based on actual results obtained in sections of the state where electric heating is used extensively and a mass of comparative data has been collected. For example, the commission estimates that a six-room house will require seven tons of coal for the average winter in Southern Idaho, which would be burned at 50 per cent efficiency in a house-heating furnace. To supply the same amount

of heat by electricity would require 25,000 kw.-hr., making the relative cost at the prevailing prices in Idaho four times as great for electric heat as for coal.

The cost of electric power is based on the testimony of an official of the Idaho Power Co. that the average cost at the consumer's meter of all energy sold by his company for operation, maintenance, insurance and taxes, but not including anything for interest on investment or for depreciation, is 0.803 cent per kilowatt-hour.

It was shown that heating by electricity 15,000 homes in the territory of the Idaho Power Co. would save 100,000 tons of coal annually, but with a considerably smaller amount of power the entire system of the Oregon Short Line could be electrified with an approximate saving of 1,000,000 tons annually. The ratio of saving is 10 to 1 in favor of the use of electricity for power in this case. Examples were cited where the ratio is even as great as 14 to 1.

Electric house heating from an economic standpoint is characterized by Dr. Merrill of the University of Utah as an "alchemist's dream," which it surely is, and should not be considered as a field for the steam power plant for the reason that it is a wasteful method of using our natural resources; and for hydroelectric plants it is an economical load only as a by-product to improve the load factor on the plant.

Power House Lighting

Wherever properly designed and installed artificial illuminating systems have been introduced, immediate benefits in the form of increased production, fewer accidents and improved welfare of the personnel of the establishment have been enjoyed. As a consequence progressive manufacturers today give as much attention to the lighting requirements of their institutions as to any phase of their business, appreciating the value of good illumination both to themselves and their employes. In fact, in many states legislation has been passed and laws are in effect which provide for a minimum degree of artificial illumination for the kind of work which may be carried on in the various industries.

Power production is essentially a manufacturing process and to a great extent is hazardous. It is therefore quite surprising in examining the tables of foot candle power intensities embodied in some of the state codes for various classes of work that no mention is made of power houses and it would therefore appear to the casual observer as if no necessity whatever existed for the proper illumination of boiler houses, engine and turbine rooms and the like. The fallacy of this is, however, at once apparent to one acquainted with the various types of machines and equipment housed in power plants, especially in those in which are installed reciprocating engines and pumping machinery and the not infrequently deadly electrical apparatus. Admittedly production in the power house is but little influenced by illumination as compared with other manufacturing processes, but efficient production and safety of the operators is of as vital importance in this industry as in any other: in fact, in many instances it is of greater importance.

What may constitute proper illumination of a power house is more or less of a problem, due, primarily, to the different types and sizes of structures employed and the various arrangements of equipment utilized. It should, however, be borne in mind that in laying out the lighting system of a power plant, reliability and continuity of operation are of first import followed only secondly by a provision for ample illumination at those points where such is necessary.

The lighting system of a power house should properly consist of two separate and distinct parts, one for the general illumination of buildings and grounds, providing for the safe movement of persons and materials, and the other for all special and local service such as the illumination of boiler gage glasses and pressure gages, oiling systems, engineers' control panels and, in fact, all positions in the plant vital to the control of the equipment and the safety of the operators. Where possible, and especially in the case of medium and large-size plants, the special or local service mains should best be provided with means whereby, if due to trouble, the source of supply may be jeopardized, service to this part of the system may immediately be restored. The storage batteries now so generally used as auxiliaries to the exciter or a specially installed steam or gasoline engine driven set may be utilized for this purpose.

For the general illumination of boiler rooms, turbine rooms, pump rooms and transformer houses, an intensity of about 4 to 5 foot candles per square foot of working surface would appear desirable, while for such points as gage and instrument boards and other important auxiliary control equipment this may to advantage be increased to 10 or 12 foot candles per square foot.

Regardless, however, of the type of system or intensities employed, satisfactory results may be expected only with proper maintenance. Frequent and periodic cleaning of the units is essential, blackened and burned out lamps should immediately be replaced and the system voltage must at all times be maintained at the value for which the lamps were designed. Failure to do so is bound to result in unsatisfactory service and excessive operating charges.

FEDERAL COST COMMISSION, Feb. 9, decided to appoint a special committee to begin the compilation of data bearing on necessity for a readjustment of prices in all fields. Decision was reached after hearing protests of many bituminous operators that they are incurring a loss under present maximum fixed prices and the 14 per cent wage increases to miners. Announcing that the purpose of the Committee was solely to facilitate consideration of price question by the Commission, Chairman Robinson emphasized the fact that the Commission was yet entirely without authority to order any readjustment of prices.

WALL STREET JOURNAL announces that France had expended for reconstruction of destroyed industrial plants up to Sept. 30 last, $572,000,000 and has rebuilt 2028 kilometers of railways out of 2245 kilometers destroyed, 657 bridges out of 1160, 700 kilometers of canals out of 1075. Out of 1,800,000 hectares of land rendered useless by war, 400,000 are now under cultivation and 200,000 additional have been cleared of projectiles.

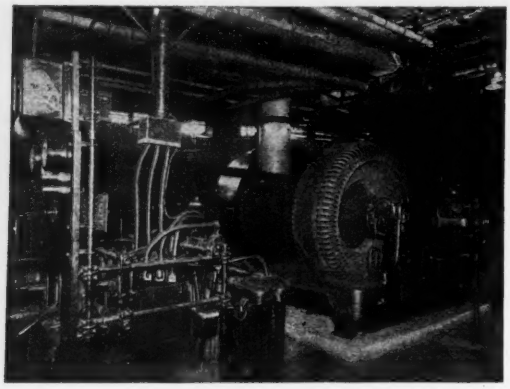
"DON'T WAIT to be pushed up the rungs—climb!"

Synchronous Motor Reduces Refrigerating Plant Costs

ANOTHER excellent example of the economy of the synchronous motor for driving ice machines is the installation in the Manhattan St. dairy of the Sheffield Farms Co., New York, where 80,000 qt. of milk are handled every day.

This plant contains four 80-ton Newburg ammonia compressors, and a 12-ton York compressor, which, before the war, were driven by steam engines. After America went to war, however, fuel was hard to get, its price rose rapidly, and the government ordered all inefficient engine-driven ice plants to be closed down. The necessity of making some change in their drive was realized by the officials of the Sheffield Farms Co., so they decided to use an electric motor and obtain power from the local lighting company.

The present drive, which is shown by the illustration, consists of a 500 hp. synchronous motor, operating on a 440-v. 60-cycle circuit, and which has a speed of 350 r.p.m. This motor is belted to a line shaft, from which all of the compressors are driven and, in addition, two 14 by 10-in. air compressors and two generators of 110 kw. and 125 kw. respectively, used for supplying current for local lighting. Current is supplied by the United Electric Light & Power Co.



SYNCHRONOUS MOTOR INSTALLATION AT DAIRY OF SHEFFIELD FARMS CO.

While this installation, being originally planned for engine drive, is not arranged in an ideal manner, nevertheless the officials state that the efficiency of the motor supplied with central station power is so much greater than that of the older drive that its savings and increase in capacity amount to $30,000 a year.

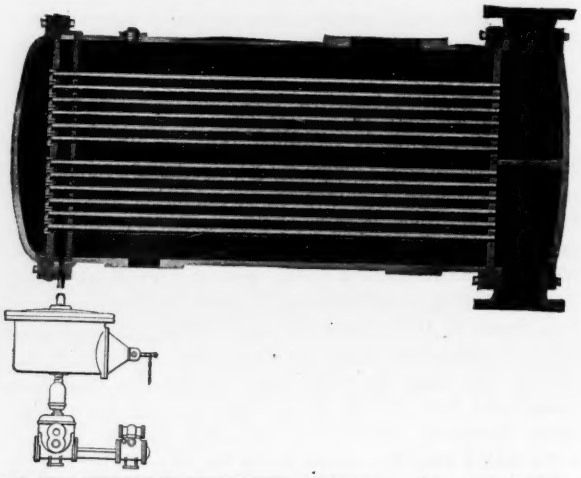
One of the interesting features of the installation which is now recognized to be of great importance in ice-plant management, is the careful attention given to the graphic meter chart which shows the amount of power being used. Since the load is practically constant under given conditions, the curve drawn by the meter should ordinarily be a straight line; but any variation in the factors of production, such as the depreciation of any part of the machinery, a change in the temperature of the brine, water, etc., or the alteration of any other detail, at once changes the power demand, which is noted by the meter. An investigation is immediately made as to the cause of the variation and correction is applied as soon as possible. Thus the efficiency of the plant is kept maximum at all times.

The use of a synchronous motor, instead of an induction motor, for this installation is in line with the present tendency in refrigerating engineering practice. The synchronous motor is favored because of its high efficiency, uniform speed, and ability to improve the power factor of the electrical system in the plant; and an ammonia compressor is well adapted to be driven by this type of motor because, with the use of bypasses, the starting conditions are light and the speed is constant.

At the Sheffield Farms plant, 110 tons of ice are produced daily from purified and filtered city water.

A New Condenser Which Eliminates Leakage Troubles

IT WAS recently brought up at a meeting of marine engineers that most of the ships now in service are experiencing trouble with leaky condensers. These leaks have been almost invariably traced to the stuffing



SECTION THROUGH CONDENSER SHOWING AUXILIARY CHAMBER AT PACKED ENDS OF TUBES

box between the tube and the tube plate. It has been found that in spite of the kind of packing used, some leakage is practically unavoidable, due to the expansion and contraction of the tube with temperature change.

The illustration herewith shows a new type of condenser developed by S. Morris Lillie. This condenser is used chiefly in connection with salt circulating water on board of ship or in regions where the water which is used for circulating purposes would be bad for boiler feed in case of leakage into the condenser and consequent mingling of the bad water with the condensate.

It will be noted on reference to the illustration that the tubes are tightly expanded into the right-hand tube plate, which eliminates the possibility of leakage at this end. At the other end, the tubes are provided with the standard ferrules and condenser packings. It is not considered good engineering practice to expand condenser tubes at both ends, because, due to constant expansion and contraction, they inevitably loosen, and leakage becomes greater than where packing is used. The packing

permits the tubes to expand freely and yet maintains an almost leakless joint. It is therefore at the left-hand end that leakage occurs, if at all.

At the left end of this condenser, a thin auxiliary tube plate or baffle is provided, through which all of the tubes are passed. The holes in this plate are of such size as to make a sliding fit with the tubes. It is obviously not necessary that these joints be absolutely water-tight.

In case of leakage of circulating water through the ferrules and packing, such leakage immediately drops down to the bottom of the compartment between the two tube plates, and is then carried off by the drain shown at the bottom, to which is attached either a small direct-acting condensate pump, or a vacuum trap, depending upon conditions.

New Electric Metal Melter

ILLUSTRATED herewith is a newly developed electrically-operated device for melting lead, babbit and similar metals and designed to eliminate loss of time and material, and risks of losses by fire, accidents, etc., which attended the melting of metals in haphazard containers, with gasoline torch to supply the heat.

TWENTY-FIVE-POUND, BENCH TYPE, ELECTRIC METAL MELTER

This new pot is of solid, durable construction, having four short legs on the bottom and a flange on the upper rim, so that it may either be stood on a table or the floor, without fear of upsetting, or lowered into a hole, so as to be flush with the top of the table. It is fitted with a plug and socket fixture that can be attached to any electric light circuit.

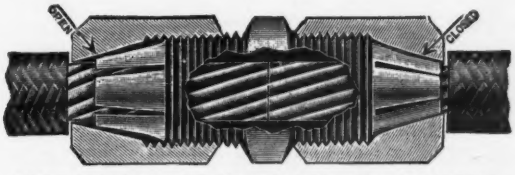
The heating element is a coil, wound around the container from top to bottom, and thoroughly insulated from the outside, thus insuring an even distribution of heat through the contents of the pot, and preventing temperature loss due to radiation.

Automatic regulation, which is the principal feature of the device, has been obtained by constructing the heating element of wire which has a positive temperature coefficient; that is, when the temperature of the heating element rises, its resistance rises proportionately, thus limiting the current and, consequently, the heat. When cold metal is put into the container, the initial rise of current is enough to melt it quickly, but, after it is melted, the current is automatically reduced to just enough to keep it molten, but not enough to burn it. This does away with the thick scum of oxidized metal around the top, which was a prominent feature of the old method. It also permits the operator to go away and leave the pot to itself when necessary without fear of wasting good metal through too much heat, or setting something on fire. With the gasoline torch, the operator had the single alternative of turning down the flame to a safe degree, which usually meant that the metal solidified and had to be melted all over again.

Due to its solid construction, automatic regulation, and safety features, this melting pot is an invaluable aid to those who see the necessity of doing away with the wasteful, inefficient and dangerous methods which have hitherto been in force.

Solderless Connectors Combine Efficiency with Economy

AFFORDING a 100 per cent efficient splice of wire or cable, that will stand maximum overload without injury, the solderless connector shown herewith represents a new method of splicing which combines reliable service with marked economy. This connector is simple in design, strong, easily installed, and made in various styles and sizes for adaption to all types of splices with all varieties of wire.



LONGITUDINAL SECTION OF TWO-WAY CONNECTOR

In making use of the two-way connector, the insulation is removed from the ends of the cable or wire, to be spliced for a distance equal to half the length of the connector. The bared ends are then inserted into the connector so that they meet at the center, after which the compression nuts are tightened. These nuts are so constructed that they force inward a set of jaws at each end of the connector, causing them to grip their respective conductors firmly, forming a perfect joint.

Splices with the other styles are made in the same manner as with the two-way type.

This connector has been approved by the National Board of Fire Underwriters. In a burnout test with No. 1 stranded cable in which both a soldered lug and a solderless connector were included in the circuit, the solder in the lug melted and caused the connection to give way, while the solderless connector withstood the test without serious injury.

A PRELIMINARY estimate made by the U. S. Geological Survey, subject to modification in the report for December and to final revision when all returns are tabulated, indicates that the production of petroleum in the United States for 1919 amounted to approximately 376,000,000 bbl.

WHEN in a fix, sweating will get you farther than swearing.—Forbes Magazine.

News Notes

THE CITY OF RACINE, Wis., has recently passed an ordinance relating to the board of examiners of stationary engineers and inspectors of steam power generating and heating apparatus. Under the provisions of this ordinance, all steam boilers, engines or any portions of steam plants or appliances when working under pressure must be in charge of a licensed engineer. Applicants for licenses must be a machinist, engineer, oiler or fireman having at least 2 yr. experience with steam boilers or engines.

U. S. CIVIL SERVICE COMMISSION announces an examination, March 9, for laboratory assistant. Vacancies in the Bureau of Mines, Pittsburgh, Pa., or elsewhere, at $900 to $1200 a year, and in positions requiring similar qualifications, at these or higher or lower salaries, will be filled from this examination. Appointees whose services are satisfactory may be allowed the temporary increase granted by Congress of $20 a month.

Competitors will be rated on elementary physics and chemistry, general education and experience. Apply for Form 1312, stating the title of the examination desired.

H. M. DAVIS died on Feb. 9, 1920, at his home in Brooklyn, N. Y., after a lingering illness of about three weeks, although for the past two or three years his general health was very poor and the end was not altogether unexpected by his many personal friends, as well as his business associates. He leaves a wife and a daughter about 11 yr. old.

Harold McGill Davis was born in Jerseyville, Ill., on Aug. 26, 1860, and was the son of Samuel W. and Mary J. McGill Davis. His early boyhood was spent in Kansas, where his father held the office of treasurer of the town of Paola, to which he was elected 13 consecutive years. Harry, as he was called by his friends, had a public school education, finishing in the St. Louis High School, after which he obtained the position of office boy in a lead and oil factory. While in high school, a cadet corps was organized and afterward mustered into the Second Regiment of the National Guards of Missouri. He became a second lieutenant and was a member of a picked squad which gave exhibition drills and fancy evolutions. After several years with the lead and oil company, he resigned and was appointed chief clerk of the St. Louis U. S. Assay Office, receiving the appointment from President Chester A. Arthur.

A Government position was too slow and uncertain for an ambitious boy, so he went to New York to study architecture. Being active in church work, he was elected president of the Brooklyn Christian Endeavor Union in 1901, an organization numbering some 6000 members, and the following year was made chairman of the printing committee in connection with the Christian Endeavor Convention held in Madison Square Garden with a total attendance of 60,000 delegates. The financial panic of 1893 offered him a chance to get into the advertising profession, in which he had some experience while in St. Louis as a writer and designer. For 4 yr. he was advertising manager of a trade paper in New York. Afterward he became connected with an advertising agency, thus broadening his experience and fitting him for his final position as manager advertising department of Sprague Electric Works of General Electric Co., which he obtained in December, 1899.

His ability as a writer and designer gave him an advantage over other solicitors which publishers were quick to recognize and resulted in the formation in leading publishing plants of what is now known as the service department.

Aside from his advertising, he frequently contributed to the papers poems both religious and humorous and articles of description.

Trade News

THE AUTOMATIC FUEL SAVING CO., of Philadelphia, has purchased from the Vapor Vacuum Heating Co. and George C. G. Gray, the patent and goodwill of the Gray System of Combustion Control for power plants. The system has been known as the Gray System and the Oilseal Combustion Control Apparatus. The new company has adopted the name of Automatic Fuel Saver, believing that this name tells the purpose of the system more simply and clearly.

W. K. EICHER, formerly with the General Electric Co. of Detroit, is now associated with the C. H. Wheeler Manufacturing Co., with headquarters at 1523 Marquette Building, Chicago.

STRONG steam traps, steam and oil separators, pump governors, valves, engine stops and other Strong steam specialties are described and illustrated in a 36-page booklet recently received from The Strong, Garlisle & Hammond Co., Cleveland, Ohio.

FROM Dominion Asbestos & Rubber Corporation, 154 Nassau St., New York, we have received Catalog No. 102 containing descriptions and illustrations of the company's packings, mechanical rubber goods and asbestos products; also folders on Griptite brake lining, Dominion branded millboard and Domino tubes.

NONPAREIL CORKBOARD INSULATION for cold rooms and boxes in dairies, creameries, fruit and produce warehouses, poultry and egg packing houses, retail and wholesale markets, etc., is the subject of an illustrated booklet from Armstrong Cork & Insulation Co., Pittsburgh, Pa.

E. B. BADGER & SONS CO., of Boston, has acquired the American Spray Co., including its essential engineering personnel.

The company announces the publication of bulletin No. 100, on cooling water by sprays; and bulletin No. 102, on cleaning air by sprays. Either of these bulletins will be sent to those interested on request.

THE PLANT ENGINEERING & EQUIPMENT CO., INC., New York City, announces the opening of its twenty-sixth office to care for the increasing demands for its products. M. Wm. Ehrlich, experienced in consulting and contracting engineering, will be the New Jersey manager in charge with headquarters at Newark, N. J., and a sub-office at Lyndhurst, N. J.